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Research and Technology Objectives and Plans Summary

Fiscal Year 1990 Research and Technology Program

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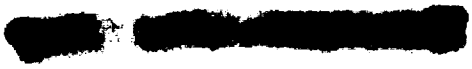

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INTRODUCTION

This publication represents the NASA research and technology program for FY 1990. 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 summaries of the RTOPs listed in ascending accession number order. 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.

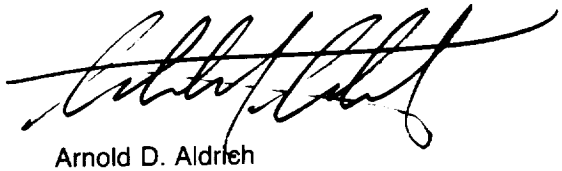
The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

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: Edna F. Templeton
Deputy Director, Resources and Management Systems Office (RB)



Arnold D. Aldrich
Associate Administrator for
Aeronautics and Space Technology

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Office of Aeronautics and Space Technology

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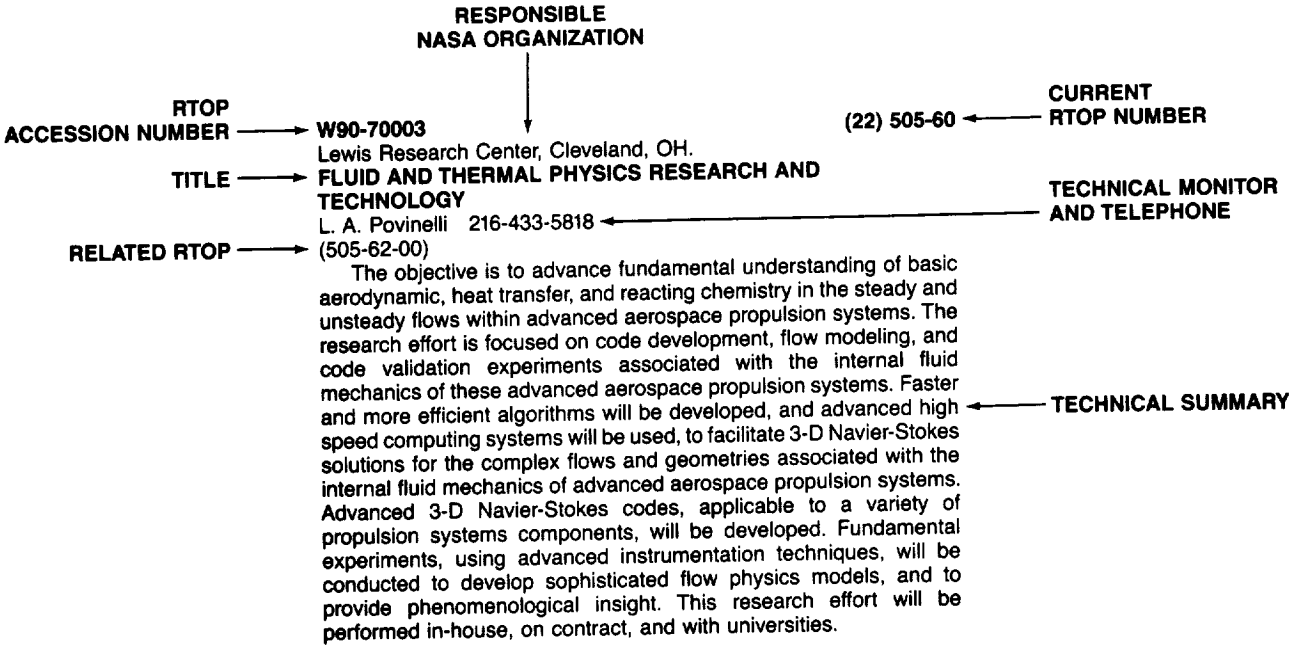


RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

a summary

FISCAL YEAR 1990

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

Fluid and Thermal Physics Research and Technology

W90-70001 **(55) 505-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
L. M. Mack 818-354-2138

This part of the Transition and Turbulence Physics Element of the Fluid and Thermal Physics research and technology program applies to the research area of laminar instability and transition. 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 numerical, analytical and experimental techniques to investigate the following problems: the mechanisms by which various external disturbance sources interact with the boundary layer and produce instability waves and other disturbances (receptivity problem); the determination of the initial conditions of the instability waves, and the relative importance of competing influences on transition; 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; the development of a method for the prediction of transition based on stability theory and knowledge of external disturbances; and 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.

W90-70002 **(21) 505-60**
Ames Research Center, Moffett Field, CA.
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. Wind tunnel experiments will be conducted to verify computer simulations and to validate prediction techniques.

W90-70003 **(22) 505-60**
Lewis Research Center, Cleveland, OH.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
L. A. Povinelli 216-433-5818
(505-62-00)

The objective is to advance fundamental understanding of basic aerodynamic, heat transfer, and reacting chemistry in the steady and unsteady flows within advanced aerospace propulsion systems. The research effort is focused on code development, flow modeling, and code validation experiments associated with the internal fluid mechanics of these advanced aerospace propulsion systems. Faster and more efficient algorithms will be developed, and advanced high speed computing systems will be used, to facilitate 3-D Navier-Stokes solutions for the complex flows and geometries associated with the internal fluid mechanics of advanced aerospace propulsion systems. Advanced 3-D Navier-Stokes codes, applicable to a variety of propulsion systems components, will be developed. Fundamental experiments, using advanced instrumentation techniques, will be conducted to develop sophisticated flow physics models, and to provide phenomenological insight. This research effort will be performed in-house, on contract, and with universities.

W90-70004 **(23) 505-60**
Langley Research Center, Hampton, VA.
FLUID AND THERMAL PHYSICS RESEARCH AND TECHNOLOGY
R. V. Harris 804-864-6048

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 and from numerous ground facilities.

Applied Aerodynamics Research and Technology

W90-70005 (23) 505-61
Langley Research Center, Hampton, VA.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
R. V. Harris 804-864-6048

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. A change to the objective is Added Supersonic Cruise and Wind-Tunnel Revitalization elements.

W90-70006 (22) 505-61
Lewis Research Center, Cleveland, OH.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
L. A. Povinelli 216-433-5818

The objective of this RTOP is: to advance the fundamental understanding of the internal fluid mechanics of hypersonic propulsion systems. The research effort is focused on the modeling of the physics of boundary layer transition, shock interactions and high speed shear layer development and applications of the modeling to CFD codes for airframe/propulsion integration. The approach is: experimental, analytical and numerical studies which will be conducted to study the physics of boundary layer transition in internal flows, shock boundary layer interactions and shear layer development and augmentation for high speed mixing applications. Direct numerical simulations will be performed to model transition physics and turbulence development. Fundamental experiments will be conducted over a range of subsonic to hypersonic flows. Models will be developed to describe internal flow physics and incorporated in 3-D Navier-Stokes codes which will be applied to airframe-propulsion integration for hypersonic aircraft. The research effort will be performed in-house and through university grants.

W90-70007 (21) 505-61
Ames Research Center, Moffett Field, CA.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
W. P. Nelms 415-694-6093
(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 engineering feasibility design studies for the aeroacoustic modification of the 40- by 80- Foot Wind Tunnel.

Propulsion and Power Research and Technology

W90-70008 (22) 505-62
Lewis Research Center, Cleveland, OH.
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 VSTOL, 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.

W90-70009 (23) 505-62
Langley Research Center, Hampton, VA.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
R. V. Harris 804-864-6048
(763-01-00)

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.

Materials and Structures Research and Technology

W90-70010 (23) 505-63
Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005

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.

W90-70011 **(22) 505-63**
Lewis Research Center, Cleveland, OH.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193
(510-01-00)

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 and modeling of the interrelationships among material composition/microstructure, fabrication processes, and mechanical/physical properties; and (2) to 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. In addition, 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.

W90-70012 **(21) 505-63**
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Howard G. Nelson 415-694-6700

The objective is to provide the materials, structures, and acoustics research and technology necessary for significant improvements in the performance, durability, and economy of future generation civil and military aircraft. In the area of materials and structures, experimental and analytical research will be performed on advanced structural materials, to better characterize and understand fatigue and fracture behaviors in order to accurately predict the life of structures when exposed to the mechanical, thermal and chemical service environments. Methods will be developed to better predict the long-term mechanical behavior of fiber reinforced plastics and monolithic and composite metallics in order to reliably predict failure. Techniques for extreme temperature (cryogenic to 3500 F) testing of advanced structural concepts and materials will be developed and tested. In the area of aeroelasticity, our capability of structural analysis will be upgraded and predictions will be correlated to measurements for the evaluation of aeroelastic computer analysis codes and to investigate new vehicle configurations. Codes will continue to be developed which simulate unsteady transonic flow with aeroelastic effects.

W90-70013 **(10) 505-63**
National Aeronautics and Space Administration, Washington, DC.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Samuel L. Venneri 202-453-2760

The objective is to conduct fundamental research on advanced materials concepts for Aeronautics. Advisory services to guide research and development 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, modeling and processing science, and computational structures technology 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.

Information Sciences Research and Technology

W90-70014 **(55) 505-65**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Daniel E. Erickson 818-354-1656
(506-44-00; 590-32-00; 591-11-00)

The objective of this task is to plan NASA's High Performance Computing Initiative (HPCI), which is part of a national effort to develop the technologies required for a thousandfold increase in supercomputer performance. Specifically, this Center will lead the Remote Exploration and Experimentation (RE and E) thrust and participate in the Earth and Space Sciences (E and SS) thrust lead by GSFC. This planning activity will generate detailed project plans for each of the thrusts of NASA's HPCI so that the multi-Center technology developments can proceed in FY-91. Elements to support the RE and E and E and SS thrusts will be added to this RTOP in FY-91. The technical work will be driven by NASA grand challenges in computing. The objective will be to demonstrate architectures, algorithms, software development tools, and operating systems which could be scaled up to meet these grand challenges. The RE and E technologies will be demonstrated in a test bed at JPL. The E and SS technologies will be demonstrated in a test bed at GSFC.

W90-70015 **(51) 505-65**
Goddard Space Flight Center, Greenbelt, MD.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Howard M. Eiserike 301-286-4030

The objective of this RTOP is to enable earth and space scientists to apply, to their data modeling and analysis requirements, the thousand-fold increase in available ground element computing power expected to be available by 1996. This will be accomplished by selecting a set of Grand Challenge problems in earth and space sciences and implementing them on testbed computers having scalable massively parallel architectures. There are classes of problems in earth and space sciences which cannot be solved on today's conventional supercomputers. Examples of these include coupled oceanic atmospheric biospheric interactions, 3-D simulations of the chemically perturbed atmosphere, solid earth modeling, solar flare modeling and 3-D compressible magnetohydrodynamics. These problems are significant in that they have both social and political implications in our society. In addition, the volume of data from the next generation of sensor instruments requires new fast algorithms to be developed for the analysis of this data. Current software and hardware systems cannot address these problems in the next few years.

W90-70016 **(21) 505-65**
Ames Research Center, Moffett Field, CA.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Marcelline C. Smith 415-694-5188
(506-44-00; 505-60-00)

The objective is to support computational aerosciences and remote exploration and experimentation by developing an

understanding of the relationships and tradeoffs between algorithms, systems software, 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; the building of prototypes to serve as proof of concept; and the establishment of scalable testbed systems.

W90-70017 **(22) 505-65**
Lewis Research Center, Cleveland, OH.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
L. A. Povinelli 216-433-5818

The objective of this work is to develop and demonstrate high performance computing techniques that will enable the integrated, multidisciplinary simulation, analysis, and optimization of aerospace propulsion system designs. Methodologies will be developed for numerically simulating the time-dependent physics of interacting propulsion components and entire systems. Resulting models, algorithms, and codes will be implemented on scalable, massively parallel architecture computers. Advanced system software will be developed to provide users with an easy-to-use computational environment for propulsion simulation and analysis. A Numerical Propulsion System (NPSS) testbed will be established to support the development and testing of the required hardware and software.

W90-70018 **(23) 505-65**
Langley Research Center, Hampton, VA.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033

Advanced computer architectures offer increased performance and greater reliability. The concurrent processing research under this RTOP addresses systems issues to enhance utilization of parallel architectures. 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. The high performance computing effort aims to accelerate the availability of appropriate computing technologies for science and engineering grand challenges. The focus of generic hypersonics research is the laboratory research, development and proof-of-concept demonstration of new sensors and non-intrusive measurement techniques for both the ground simulation and flight test of supersonic/hypersonic flow regimes. Concurrent processing issues to be studied include programming languages and environments, problem decomposition and algorithm development, and comparison of prototype architectures for real time computing. 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 ICASE, and the ICLASS block grant supports related research.

W90-70019 **(62) 505-65**
Marshall Space Flight Center, Huntsville, AL.
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.

Controls and Guidance Research and Technology

W90-70020 **(23) 505-66**
Langley Research Center, Hampton, VA.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033

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 agility controls and pilot interface technology, windshear detection and avoidance, 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 multidisciplinary interactions.

W90-70021 **(51) 505-66**
Goddard Space Flight Center, Greenbelt, MD.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
Gene E. Godwin 804-824-1217

The overall objective of this RTOP is to provide operational support to approved Office of Aeronautics and Space Technology (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 flight services; crash, fire, and rescue services; specialized instrumentation and miscellaneous equipment.

W90-70022 **(21) 505-66**
Ames Research Center, Moffett Field, CA.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
G. W. Condon 415-694-5567
(505-61-00; 505-67-00)

The objective of this research is to develop a guidance and control technology base for design of safe, efficient civil and military aircraft. Research will be conducted on: advanced, robust flight/propulsion control systems for highly augmented aircraft; advanced guidance, navigation, 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.

Human Factors Research and Technology

W90-70023 **(21) 505-67**
Ames Research Center, Moffett Field, CA.
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 design principles; to monitor flight crew performance, assist flight crews in contingency operations, and improve aviation system reliability and precision; and to develop crew/vehicle interfaces and operational concepts that will improve aviation safety by supporting more effective crew performance and by enhancing crew capabilities. The approach emphasizes mathematical and computational modeling of human sensory, perceptual, cognitive, and communicative abilities. Computational 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, to design and prototype information management and display systems which improve pilot situation awareness, and to delineate aeronautical vehicle guidelines for systems and procedures.

W90-70024 **(23) 505-67**
Langley Research Center, Hampton, VA.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(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 crew station concepts involving cockpit displays of flight management information that will exploit the efficient and safe use of emerging cockpit system technology; the development and validation of human response measurement technologies for the assessment of aerospace crew mental state; and the establishment of a quantitative and qualitative data base for display format/arrangement factors.

W90-70025 **(10) 505-67**
National Aeronautics and Space Administration, Washington, DC.
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.

Flight Systems Research and Technology

W90-70026 **(23) 505-68**
Langley Research Center, Hampton, VA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. V. Harris 804-864-6048
(533-02-00)

The objective of this RTOP is to: develop 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; utilize flight experiments to validate key elements; and 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, for the development of design and operating criteria for those hazards which cannot be avoided, and to complete flight testing of an F-106 aircraft modified with vortex flaps.

W90-70027 **(21) 505-68**
Ames Research Center, Moffett Field, CA.
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 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, in-house and contracted studies are being conducted to evaluate supersonic single engine concepts featuring different propulsive lift systems. Following a U.S./U.K. downselect process, a focused technology program will be conducted, including piloted simulation using the Vertical Motion Simulator.

W90-70028 **(22) 505-68**
Lewis Research Center, Cleveland, OH.
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 research and technology 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 STOVL 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 STOVL aircraft.

Systems Analysis Research and Technology

W90-70029 **(22) 505-69**
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
D. C. Mikkelson 216-433-5637
(537-01-00)

The objective of this RTOP is to perform studies of the feasibility and potential benefits of advanced subsonic, supersonic, and hypersonic propulsion concepts and to identify technology research requirements and define opportunities for capitalizing on technology advances. Computer models will be developed for and 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.

W90-70030 **(21) 505-69**
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
George H. Kidwell, Jr. 415-694-5886

The fundamental objective of this activity is to develop information to guide the planning of advanced aircraft research programs. Current efforts are directed toward the National Aero-Space Plane program, the High Speed Rotorcraft program, and the High Altitude Atmospheric Research Platform program. Data will be produced based on two philosophies. The first is that a thorough analysis of distinct classes of aircraft applicable to specific missions is critical to the process of determining the most advantageous concept(s) to pursue. Both in-house and contracted studies will be undertaken to perform the technical evaluation and sensitivity analysis of fully integrated design candidates of each. The alternate, but complementary, approach is to assess the impact of emerging technologies, alternative missions, or other innovative concepts applied to appropriate baseline designs. In-house studies addressing questions of this type will be performed as potentially-high value concepts are identified.

W90-70031 **(23) 505-69**
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
R. V. Harris 804-864-6048

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. Research addresses vehicles for both civil and military applications across the speed range, and is focused on transportation needs and identification of the most promising future vehicle concepts based on an evaluation of the technical, economic, and timing issues.

W90-70032 **(10) 505-69**
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Cecil C. 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 of the University Advanced Aeronautical Design Studies Program.

Interdisciplinary Technology

W90-70033 **(23) 505-90**
Langley Research Center, Hampton, VA.
INTERDISCIPLINARY TECHNOLOGY
R. W. Barnwell 804-864-6059

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 leading edge of the latest technology and techniques in science, engineering, mathematics, and computers.

W90-70034 **(21) 505-90**
Ames Research Center, Moffett Field, CA.
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. Funds for Independent Research support innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. 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.

W90-70035 **(22) 505-90**
Lewis Research Center, Cleveland, OH.
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.

W90-70036 **(10) 505-90**
National Aeronautics and Space Administration, Washington, DC.
INTERDISCIPLINARY TECHNOLOGY
Edna Templeton 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 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

W90-70037 **(22) 510-01**
Lewis Research Center, Cleveland, OH.
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 revolutionary advances in high temperature engine 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, light weight 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; and advanced polymeric 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.

W90-70038 **(22) 510-02**
Lewis Research Center, Cleveland, OH.
ADVANCED COMPOSITE MATERIALS TECHNOLOGY
C. C. Chamis 216-433-3252
(505-63-00; 590-21-00)

The major objective of the Advanced Composites Technology RTOP is to develop an integrated technology data base that provides impetus for cost effective use of advanced composite materials in the primary structures of future aircraft. Included in this is the development of a structural mechanics technology data base that provides the scientific understanding of failure mechanisms and establishes true limits of performance so that design and analysis procedures may be applied to the primary structures. The research includes application of probabilistic analysis methods to predict the response, fracture, durability and life of composite structures.

W90-70039 **(23) 510-02**
Langley Research Center, Hampton, VA.
ADVANCED COMPOSITE STRUCTURES TECHNOLOGY PROGRAM
C. P. Blankenship 804-864-6005

The research includes advanced concept development, analysis, fabrication, testing, and demonstration programs in composite 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 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

W90-70040 **(21) 532-06**
Ames Research Center, Moffett Field, CA.
ADVANCED ROTORCRAFT TECHNOLOGY
W. Snyder 415-694-6570
(505-61-00)

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 defined.

W90-70041 **(23) 532-06**
Langley Research Center, Hampton, VA.
ADVANCED ROTORCRAFT TECHNOLOGY
C. P. Blankenship 804-864-6005
(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

W90-70042 **(21) 533-02**
Ames Research Center, Moffett Field, CA.
HIGH-PERFORMANCE FLIGHT RESEARCH
Calvin R. Jarvis 805-258-3177
(505-68-00)

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 (CAS) technology development. The F-15 Performance Seeking Control (PSC) program will complete the design and development effort to optimize the total integrated propulsion and flight control system, with subsequent flight test of key systems and modes. The modified YAV-8B Harrier will be used to validate designed methodologies for integrated flight and propulsion controls and develop design criteria for advanced STOVL aircraft. 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. Flight research of a supersonic laminar flow glove with a suction system will be completed.

W90-70043 **(23) 533-02**
Langley Research Center, Hampton, VA.
HIGH-PERFORMANCE FLIGHT RESEARCH
R. V. Harris 804-864-6048
(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 validation/demonstration of high angle of attack aerodynamics technology applicable to fighter airplanes. The approach to be used will combine full-scale flight and wind-tunnel testing. The focus for high angle-of-attack technology validation will be the NASA F-18 High-Alpha Research Vehicle (HARV) at NASA-Dryden. This program involving Ames, Dryden, LeRC, 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

W90-70044 **(21) 535-03**
Ames Research Center, Moffett Field, CA.
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 verify advanced CFD techniques.

W90-70045 **(22) 535-03**
Lewis Research Center, Cleveland, OH.
ADVANCED TURBOPROP SYSTEMS
J. A. Ziemianski 216-433-3901

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

W90-70046 **(23) 535-03**
Langley Research Center, Hampton, VA.
ADVANCED TURBOPROP SYSTEMS
C. P. Blankenship 804-864-6005

The objective of the program is to develop both aerodynamic and acoustic technology necessary for the design of future advanced turboprop/ducted fan/unducted fan powered aircraft. Configurations of interest are powered by highly loaded, multi-bladed, single-rotating and counter-rotating propeller systems and large ducted fan systems. Emphasis is on prediction and control of propeller/fan 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/unducted fan propellers, ducted fans, and aircraft configurations.

W90-70047 **(22) 535-05**
Lewis Research Center, Cleveland, OH.
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. This approach will provide industry with the capability to design and build small engines with performance, maintainability, and durability approaching that of large engines. The technology involved, 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

W90-70048 (21) 536-01
Ames Research Center, Moffett Field, CA.
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 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 four elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, the operation of the NPSN and an applied research effort in high performance computing architectures, algorithms and systems technology. This RTOP covers the overall management of the Program, the facility, the development of the processing system and computational system research. 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.

W90-70049 (21) 536-02
Ames Research Center, Moffett Field, CA.
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 four elements--the computer processing system (the NAS Processing System Network or NPSN), the facility to house the associated machines and people, the operation of the NPSN and an applied research effort in high performance computing architectures, algorithms and systems technology. 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.

High-Speed Research

W90-70050 (21) 537-01
Ames Research Center, Moffett Field, CA.
HIGH SPEED RESEARCH - ATMOSPHERIC EFFECTS
Richard L. Kurkowski 415-694-6569
(537-02-00; 537-03-00)

The objective is to conduct a program of theoretical and experimental research to assess the atmospheric effects of a fleet of high-speed civil transport aircraft. Issues to be addressed include depletion of stratospheric ozone, perturbations to atmospheric chemistry on a global scale, and the potential for long term climate change. Aircraft system studies will be conducted to determine the technological requirements for environmental compatibility and economic viability. Rapid turn around sensitivity studies will be performed to identify the potential benefits and risk of alternate approaches to key program questions.

W90-70051 (23) 537-01
Langley Research Center, Hampton, VA.
ATMOSPHERIC EFFECTS
R. V. Harris 804-864-6048

The overall objective of this work is to provide guidance and direction to aeronautics research and technology programs performance by NASA and the Nation's aviation industry to assure that any future fleet of High-Speed Civil Transports (HSCT's) would not have a detrimental effort on Earth's atmosphere. Available atmospheric models will be used and improved to assess the effects of a projected fleet of HSCT's on global ozone, stratospheric climatology, and the stratospheric-tropospheric radiative balance. An advisory committee of experts in the field will review the results that will be used to evaluate possible emissions budgets. Aircraft systems studies will be conducted to identify those high-payoff technology developments that will enable the development of an economically viable and environmentally acceptable HSCT. Technical solutions for various environmental concerns will be combined to determine the synergistic effects on aircraft operational characteristics. Operational methods and/or flight paths will be developed to enhance environmental compatibility, and systems studies will provide necessary inputs to assess community noise and sonic boom levels. The systems studies will provide guidance to discipline specialists in selecting the most promising solution or combination of solutions.

W90-70052 (22) 537-01
Lewis Research Center, Cleveland, OH.
HIGH SPEED RESEARCH - ATMOSPHERIC RESEARCH
R. J. Shaw 216-433-3942
(537-02-00; 505-69-00)

Detailed studies will be performed to determine the economic penalties associated with satisfying environmental constraints for a potential high speed civil transport. Specifically, a spectrum of novel propulsion system concepts will be investigated in sufficient depth to identify optimum cycle parameters and preferred engine types to minimize the adverse affects of complying with expected airport noise and cruise emission constraints. Key technology needs will be identified and the overall program plans adjusted accordingly. The plan is to evaluate advanced variable cycle engines, advanced noise suppression concepts and advanced combustors to identify the most promising concepts for supersonic civil aircraft.

W90-70053 (22) 537-02
Lewis Research Center, Cleveland, OH.
EMISSIONS AND SOURCE NOISE
R. J. Shaw 216-433-3942

The overall objective of this effort is to explore advanced concepts in propulsion emissions and noise reduction, and develop engine component technology for future supersonic transports leading to no stratospheric ozone-layer damage and compliance with Federal Aviation Regulation (FAR) Part 36 - Stage 3 noise levels.

W90-70054 (21) 537-02
Ames Research Center, Moffett Field, CA.
HIGH SPEED RESEARCH - EMISSIONS AND SOURCE NOISE
Richard L. Kurkowski 415-694-6569
(537-01-00; 537-03-00)

The objective is to develop combustion technologies and operational procedures that ensure no significant atmospheric ozone depletion from a fleet of high speed civil transport aircraft. The goal of the emissions element of the High Speed Research Program (HSRP) is to develop NO(x) control technologies such that NO(x) production levels will be in the 3 to 8 g/kg (Emission

Index) range. Advanced computation methods and computer codes will be developed and used to model the reacting turbulent flow in candidate combustor configurations. Emphasis will be given to the computational chemistry determination of the chemical kinetics and thermodynamic database required to accurately model the flow. Future supersonic transports must comply with Federal Aviation Regulation (FAR) Part 36 - Stage 3 noise levels. To help meet such constraints this effort will develop and verify advanced aerodynamic analysis and noise prediction capability through higher-fidelity computational models and controlled laboratory experiments using advanced flow-field measurements.

W90-70055 **(23) 537-02**
Langley Research Center, Hampton, VA.
EMISSIONS AND SOURCE NOISE
C. P. Blankenship 804-864-6005
(505-61-11)

The objective of this research is to develop an advanced and validated base of supersonic jet noise reduction technology for application to future civil supersonic transports. The goal is technology to support an economically viable transport compliant with Federal Aviation Regulation (FAR) Part 36 - Stage 3. Analytical, computational, and experimental approaches are included in research that is conducted in-house and by grant and contract. Improved understanding of the physical mechanisms by which supersonic flows generate noise is sought, and theories and validating data bases for accurate noise prediction and reduction are developed. The experimental portion of the program emphasizes model scale laboratory studies under controlled conditions.

W90-70056 **(23) 537-03**
Langley Research Center, Hampton, VA.
COMMUNITY NOISE AND SONIC BOOM
R. V. Harris 804-864-6048

The overall objective of this work is to provide an understanding, predictive capability, and minimization methodology for the acoustic disturbances generated by the operation of a High-Speed Civil Transport (HSCT). An HSCT must be compliant with the intent of Federal Aviation Regulation (FAR) Part 36 - Stage 3 noise rules to be allowed to take off and land at existing international airports. Meeting community noise rules will most likely impose the severest weight and efficiency penalties of the environmental concerns. Validated noise prediction and suppressor technology will be developed, as well as improved high lift systems to enable flight path optimization. Sonic boom prediction, propagation, minimization, and human perception must be better understood. Research to minimize the annoyance factor by shaping the sonic boom signature and an assessment of public reaction to different types and amplitudes of sonic booms will establish the feasibility of supersonic overland flight. Methods that predict the effect of aircraft maneuvering, sonic boom focusing, and secondary booms will be developed. A flight experiment and accompanying transition prediction and design methodology will develop and validate technology for practical, reliable, and maintainable supersonic laminar flow control concepts for HSCT application. Laminar flow control offers the potential to dramatically reduce the takeoff gross weight by increasing vehicle efficiency and thus reduce the magnitude of environmental concerns, as well as increase the economic viability of HSCT's.

W90-70057 **(21) 537-03**
Ames Research Center, Moffett Field, CA.
HIGH SPEED RESEARCH - COMMUNITY NOISE AND SONIC BOOM
P. Kutler 415-694-6569
(537-01-00; 537-02-00)

The objective is to develop the design methodology to reduce community noise (i.e., takeoff and approach noise) to Federal Aviation Regulation (FAR) Part 36 - Stage 3 levels and to minimize the sonic boom impact. In the first category, the research involves the development of accurate system noise prediction methodologies for supersonic transport aircraft, optimized engine placement for minimum noise impact, and efficient, low-speed, high-lift systems. In the sonic boom area, the research will concentrate on the development of low boom concepts and predictive methodology utilizing CFD. In a supporting area, the practical implementation of laminar flow control on highly swept wings at supersonic speeds offers the potential for significant reductions in cruise drag, thereby decreasing engine thrust requirements, engine size/weight, and noise. Therefore, research will be conducted to provide the technology base, including design criteria and predictive technology, for the practical implementation of laminar flow control techniques.

Space Research and Technology Base

Aerothermodynamics Research and Technology

W90-70058 **(23) 506-40**
Langley Research Center, Hampton, VA.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
W. R. Hook 804-864-6055
(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 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, Mach number, and Reynolds 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 and utilizes the unique capabilities of the Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel.

W90-70059 **(21) 506-40**
Ames Research Center, Moffett Field, CA.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
James 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 Energy Conversion Research and Technology

W90-70060 **(21) 506-41**
Ames Research Center, Moffett Field, CA.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Edwin L. Force 415-694-3755
(591-34-00)

The objective of the Environmental Control and Life Support element of the Space Energy Conversion research and technology program is to develop new and improved physical/chemical process technologies for air revitalization, water reclamation and solid waste management that will provide the basis for integrated, closed-loop life support systems. A further objective is the development of advanced regenerable technologies for portable life support systems that will provide both rapid turnaround capability and extended extravehicular activity (EVA). The approach chosen for meeting these objectives is based on the use of process modeling. State-of-the-art commercial simulation programs will be used to prepare fundamental models of physical/chemical life support process technologies. These process models will be used for performance evaluations, research and development program guidance and the synthesis of more complex models of integrated, closed-loop life support subsystems and systems. Laboratory-based experimental studies will be performed as necessary to develop fundamental data for improving and validating these models. New concepts and ideas for life support process technologies also will be investigated through a combination of both simulation modeling and experimental studies. Supporting activities will include the development of sensor and instrumentation technologies and the implementation of an advanced life support database.

W90-70061 **(51) 506-41**
Goddard Space Flight Center, Greenbelt, MD.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Theodore 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 testing of various two-phase components and test verifications; and (3) small flight experiments.

W90-70062 **(72) 506-41**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
A. F. Behrend 713-483-9241

The objectives of this RTOP effort are the development of 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 human space missions 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 planetary transit vehicles 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.

W90-70063 **(23) 506-41**
Langley Research Center, Hampton, VA.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
W. R. Hook 804-864-6055

This program is part of the power management effort. It contains three research areas: laser space power transmission, advanced power management, and advanced power propulsion (P/P) concepts analysis. The goal of the laser area is to assess the technical feasibility and develop key technologies for power transmission, in support of civil space missions, for propulsion and for electric power distribution. 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 being studied is laser photovoltaic conversion. Research on this concept is both experimental and theoretical. 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 two thermal energy control technologies, liquid droplet (L.D.) radiators and L.D. heat exchangers, which offer 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 conceptual system designs and technology requirements.

W90-70064 **(22) 506-41**
Lewis Research Center, Cleveland, OH.
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 and surfaces, 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 atomic oxygen, plasma and radiation environment while reducing cost and mass, where appropriate, 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.

W90-70065 **(10) 506-41**
National Aeronautics and Space Administration, Washington, DC.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Gregory M. Reck 202-453-2847

The objective 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.

W90-70066 **(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 area of power switching and control; chemical energy conversion; photovoltaic energy conversion; and thermal energy conversion for spacecraft power systems up to 40kW. The principal goal is to develop high density power technologies that minimize power system mass and volume. Also, we seek to meet the power requirements of future missions that may include rovers, penetrators, and high temperature/pressure operation. Specific goals are: progress in power switching and control functions from discrete to monolithic technologies leading to increases in power density from 1W/cu. in. to 10W/cu. in.; development and demonstration of photovoltaic array technology that produces nearly 300 W/kg and 300 W/sq m for near sun and electric propulsion missions; high cycle life, 100 W-hr/kg rechargeable batteries; and thermal-to-electric conversion technologies capable of efficiencies of at least 10 percent (thermoelectrics) or 20 percent (AMTEC). The approach includes industry tasks for prototype demonstration elements and university tasks.

Propulsion Research and Technology

W90-70067 **(55) 506-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPULSION RESEARCH AND TECHNOLOGY
P. W. Garrison 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 near-term 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 FY-90 will emphasize resolution of fundamental ion engine life-limiting processes and critical system issues, and examination of the effects of an applied magnetic field on MPD thruster operation. 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 electric propulsion, nuclear fission and 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.

W90-70068 **(22) 506-42**
Lewis Research Center, Cleveland, OH.
PROPULSION RESEARCH AND TECHNOLOGY
L. A. Diehl 216-433-2438
(590-21-00; 591-41-00)

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 and spacecraft, orbital transfer vehicles, planetary spacecraft, 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.

W90-70069 **(10) 506-42**
National Aeronautics and Space Administration, Washington, DC.
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.

W90-70070 **(23) 506-42**
Langley Research Center, Hampton, VA.
PROPULSION RESEARCH AND TECHNOLOGY
W. R. Hook 804-864-6055

The objective is to develop an integrated propulsion evaluation system for earth-to-orbit, orbit-to-orbit, lunar, and planetary transfer vehicles. The approach is to enhance and validate a rocket propulsion model that computes specific impulse, thrust, and weight from a set of propulsion parameters that include propellants, cycle, nozzle, and chamber pressure and integrate this model with a trajectory optimization program coupled to a vehicle weights and sizing program. This integrated system can be used to determine vehicle size and weight for a given propulsion system, optimize propulsion parameters for a given vehicle and mission, and optimize a vehicle given the propulsion system and mission.

W90-70071 **(62) 506-42**
Marshall Space Flight Center, Huntsville, AL.
PROPULSION RESEARCH AND TECHNOLOGY
James E. Clark 205-544-6728

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 Advanced Transportation Propulsion include: (1) investigation of high area ratio nozzle concepts with extendible nozzles made of lightweight materials employing radiation cooling

techniques. (2) Other areas of investigation are the development of analytical techniques/methods for evaluating combustion chamber performance and the effects of nozzle boundary layer, and liquid/liquid jet interaction - atomization characteristics. (3) Explore the feasibility of applying recent advances in high temperature superconductivity to turbomachinery magnetic bearings and to magnetic deflection of engine exhaust plume for thrust vector control. These new superconducting materials do not require cooling below the normal boiling temperature of contemporary cryogenic rocket propellants.

Materials and Structures Research and Technology

W90-70072 (23) 506-43
Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005

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.

W90-70073 (51) 506-43
Goddard Space Flight Center, Greenbelt, MD.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Roy McIntosh 301-286-3478

The overall objective of this plan 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.

W90-70074 (21) 506-43
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
James O. Arnold 415-694-5265
(506-40-00; 506-48-00; 591-42-00)

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, understanding hydrogen compatibility of advanced structural materials, 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 and metallic 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 space transfer vehicles (ASTV), 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.

W90-70075 (72) 506-43
Lyndon B. Johnson Space Center, Houston, TX.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Steven L. Koontz 713-483-5906
(506-44-33)

This RTOP will provide funds to support continuing laboratory studies of space durable materials. The data base produced by these studies will support design and development of Space Station, other long lived LEO platforms, and the Moon - Mars initiative. Material and protective coating concepts providing long life in the LEO, Lunar and Martian environments will be identified. Factors limiting the life of important material classes will also be identified. The data base produced by these studies will lead to high confidence design of long-lived, low-maintenance spacecraft and space facilities. This RTOP will also provide funds to examine the effects of hypervelocity impact on non-metallic materials, investigate new shielding concepts, and begin investigation of debris sweeper concepts. The examination of the hypervelocity impact resistance of non-metallic materials and new shielding concepts will be conducted in the JSC Hypervelocity Impact Research Laboratory. Damage produced by debris plumes formed during hypervelocity impacts on thin sheets of non-metallic materials will be emphasized in this study.

W90-70076 (22) 506-43
Lewis Research Center, Cleveland, OH.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193

The objectives of this RTOP 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 explore new ceramic matrix composites for aerospace applications; (4) exploration of new materials for heat storage and space power applications; and (5) fundamental chemistry of conductive polymer composites. The analytical and experimental results of this RTOP will have far reaching practical applications for a wide range of aerospace materials, structures, and components.

W90-70077 (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. Greater understanding of the correlation between molecular parameters and observed physical and mechanical properties will lead to a

capability for producing materials with specific mechanical characteristics. Emphasis will be placed on development of materials with submicron dimensional stability for extended periods of time in space. Analytic capability which includes design optimization, fabrication, testing and performance prediction of advanced structural composite materials has been developed and will be extended to carbon-carbon composites. 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 material space degradation pathways and effects of space environment on materials. Development of ground-based testing methodology will be emphasized. Research on flexible structure dynamics will be concentrated on development of uncertainty models and concepts for adaptive deployable structures.

W90-70078 **(10) 506-43**
National Aeronautics and Space Administration, Washington, DC.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Samuel L. Venneri 202-453-2760

The objective of this RTOP 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.

Space Data and Communications Research and Technology

W90-70079 **(55) 506-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Daniel E. Erickson 818-354-1656
(506-45-00; 590-32-00)

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-strength 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, tools, and approaches while it also branches out to investigate 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 communications 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.

W90-70080 **(51) 506-44**
Goddard Space Flight Center, Greenbelt, MD.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Mike Fitzmaurice 301-286-6610

This RTOP will develop and demonstrate the advanced transmitter and receiver technology required for high performance spaceborne laser communication systems, and 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 will be to: (1) develop AlGaAs semiconductor lasers in both single unit and monolithic array configurations, and improve the sensitivity of direct detection receivers using Si and III-V avalanche photodiode technology; (2) perform research in 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; and (3) 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.

W90-70081 **(22) 506-44**
Lewis Research Center, Cleveland, OH.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
Denis J. Connolly 216-433-3503
(590-33-00)

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 technology for high frequency spacecraft components, such as switches, power amplifiers, low noise amplifiers, mixers, oscillators, and phase shifters.

W90-70082 **(72) 506-44**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
B. Ho 713-483-4936

Areas of research in this RTOP include new models, methodologies, and paradigms to advance the life-cycle engineering of software, especially software that supports mission and safety critical (MASC) components; productivity tools for software development and maintenance; development and maintenance of distributed information systems, especially non-stop embedded systems; NASA software engineering training requirements; advancements in operating systems and network operating systems; advancements in computer networks; software fault tolerance and systems survivability; multi-level computer security and integrity; use of the Ada language and associated environments on NASA projects; and application of Expert Systems and Artificial Intelligence techniques to life-cycle software management. 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 liaison 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).

W90-70083 **(21) 506-44**
Ames Research Center, Moffett Field, CA.
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 autonomous operation, onboard computational capability, and 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 and a simulator on the Connection Machine 2 of a Sparse Distributed Memory architecture developed by Kanerva is being tested to determine its applicability to several space science applications.

W90-70084 **(23) 506-44**
Langley Research Center, Hampton, VA.
SPACE DATA AND COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(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

W90-70085 **(21) 506-45**
Ames Research Center, Moffett Field, CA.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Craig R. McCreight 415-694-6549
(590-31-00)

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 400 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 airborne and spaceborne applications. This research is centered around two major subtasks: development of real-time optical processors for on-board data analysis, and the integration of optical processors with higher-level expert systems for image understanding and control of intelligent systems. These research objectives will be accomplished by coordinating extensive in-house technology demonstrations with user requirements for applications in autonomous construction, exploration, and control.

W90-70086 **(51) 506-45**
Goddard Space Flight Center, Greenbelt, MD.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Henry H. Plotkin 301-286-6185

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, which will enable future evolution of astronomical and planetary missions such as Astromag, Mars Observer, Gamma Ray Observatory, and Lunar Material studies. Research tasks include silicon detector arrays for high resolution imaging spectrometers for soft X-rays (below 30 KeV) and high energy cosmic rays, mercuric iodide arrays for room temperature spectrometers for soft and gamma X-rays, and low temperature X-ray microcalorimeters operating at the quantum limit of detectability.

W90-70087 **(23) 506-45**
Langley Research Center, Hampton, VA.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Frank Allario 804-864-6027

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.

W90-70088 **(55) 506-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
Virendra Sarohia 818-354-6758

This task develops technologies which will enhance sensing and management of space-derived information, and performs advance research in information science and photonics technology in space. For passive and remote sensing, research is being conducted in new III-V material systems and novel device structures for high performance long wavelength infrared (LWIR) detectors, suitable for fabrication into advanced IR focal plane arrays. In addition thin films of high Tc superconductors will be developed for use in submillimeter wave detection and generation, and millimeter wave signal transmission. Research on 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 on-board optical computing.

W90-70089 **(10) 506-45**
National Aeronautics and Space Administration, Washington, DC.
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 requirements, complementary work in other government agencies, and forecasts of new technical developments.

Controls and Guidance Research and Technology

W90-70090 **(55) 506-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
A. Fernando Tolivar 818-354-6215

The objective is 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 orbiting science platforms, space interferometers, the evolutionary space station, orbit transfer vehicles, and advanced earth orbiters and planetary spacecraft. The approach is to develop: advanced computational tools required for control analysis, synthesis and simulation of future space systems; system identification techniques and software for automated monitoring of system performance, adaptive control designs for autonomous compensation of dynamic uncertainties and/or configuration change; two advanced guidance and control components - FORS, a long-life all-solid-state integrated optics fiber gyro, and SHAPES, an optical, 3-dimensional position sensor for static and dynamic figure measurement and dynamic identification of flexible spacecraft; sub-micron accuracy control sensor components and concepts for future large optical space interferometers; and controls and guidance concepts for future aeromaneuvering spacecraft.

W90-70091 **(51) 506-46**
Goddard Space Flight Center, Greenbelt, MD.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
Harold P. Frisch 301-286-8730

The objective of this RTOP in computational controls is to achieve a 2 to 4 order 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. Any 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 needs. All results will be recorded in the Library of Multibody Test and Validation data currently under development. Interactive control system design and analysis tools have increased the productivity of project support engineers by orders of magnitude. The Goddard Space Flight Center (GSFC) developed program INCA satisfies all classical linear single input/output controls design and analysis needs. It is essential that multivariable, nonlinear, optimal control and other related methods be made accessible to project support engineers. This will be done.

W90-70092 **(62) 506-46**
Marshall Space Flight Center, Huntsville, AL.
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.

W90-70093 **(72) 506-46**
Lyndon B. Johnson Space Center, Houston, TX.
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 elements, including the Shuttle, OMV, STV, MMU, free-flyers, aeromaneuvering planetary and earth return vehicles and the Space Station. Studies will be directed toward technology developments which have the broadest application to these fleet elements and which integrate 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.

W90-70094 **(23) 506-46**
Langley Research Center, Hampton, VA.
CONTROLS AND GUIDANCE RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(585-01-00)

The objective of this RTOP 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, including hypersonic vehicles, 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.

Human Factors Research and Technology

W90-70095 **(72) 506-47**
Lyndon B. Johnson Space Center, Houston, TX.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
Barbara 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 the 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.

W90-70096 **(21) 506-47**
Ames Research Center, Moffett Field, CA.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
M. G. Shafto 415-694-6170
(505-67-00; 591-32-00; 506-41-00)

To ensure high levels of safety and productivity for future space missions, research is conducted in two areas: crewstation design and extravehicular activity. 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, end effectors, and portable life-support systems 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 in operational contexts at other NASA Centers. Advanced suits, gloves, and portable life-support concepts will be developed, prototyped, and tested at Ames and JSC to provide proofs of concept.

W90-70097 **(55) 506-47**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HUMAN FACTORS RESEARCH AND TECHNOLOGY
A. K. Bejczy 818-354-4568

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.

Space Flight Research and Technology

W90-70098 **(55) 506-48**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. H. Kelley 818-354-7068

Eight technology themes have been identified within the In-step Space Technology Experiments (Outreach and Inreach). For all eight themes, JPL will provide programmatic support to NASA-HQ in areas of planning, reviewing, technology oversight, management and coordination with team members from other centers. Periodic technology working group meetings for each theme will be attended and documents describing the working groups recommendations will be produced. In addition, JPL will chair the automation and robotics theme group, (one of the eight). This effort also includes a limited budget set aside for responding to an expected call for FY-90 Inreach flight experiments.

W90-70099 **(21) 506-48**
Ames Research Center, Moffett Field, CA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
James 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 have been designed, developed, and fabricated through both in-house and contract efforts.

W90-70100 **(51) 506-48**
Goddard Space Flight Center, Greenbelt, MD.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
Roy McIntosh 301-286-3478

The objective of this program is to develop a database descriptive of the Avionic and Control System Hardware (ACSH) developed and under development by Code 740. This data base

will be developed in such a manner that unique combinations of subassemblies of this ACSH can be organized and assembled to support quick reaction of technology demonstrations in space where excess booster capability exists. This program will also determine and document the excess payload capability of U.S. Expendable Launch Vehicle (ELV).

W90-70101 **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
Robert Spann 713-283-5431

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 initiation. Additionally, for the in-space experiments programs, to provide experiment accommodation assessment for selected proposals prior to initiation of Phase A concept and development Phase B engineering studies; and Phase C/D hardware development and flight; make recommendations concerning complementary/compatible experiment groupings; and possible experiment flight opportunities.

W90-70102 **(22) 506-48**
Lewis Research Center, Cleveland, OH.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
E. P. Symons 216-433-2853
(591-23-00; 592-01-00)

The objective of the Space Flight research and technology program is to provide for the flight verification and evaluation of advanced technologies for future space systems. The program elements contained in this submittal include Cryogenic Fluid Management and Experimental Outreach Studies. The Cryogenic Fluid Management element of the Space Flight research and technology 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 experiment support, test facilities, accommodation assessments, and development of advanced in-space flight technology experiments with the aerospace industries and universities which will enable validation and verification of the technologies using the nation's space facilities.

W90-70103 **(23) 506-48**
Langley Research Center, Hampton, VA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
W. R. Hook 804-864-6055
(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.

W90-70104 **(62) 506-48**
Marshall Space Flight Center, Huntsville, AL.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-4176

The overall objective of this research is to provide for the flight verification and evaluation of advanced technologies for future space systems. Different technologies are included; each requiring the environment afforded by an in-flight demonstration to be verified.

Systems Analysis

W90-70105 **(62) 506-49**
Marshall Space Flight Center, Huntsville, AL.
SYSTEMS ANALYSIS
James E. Clark 205-544-6728

The objective of this study is 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. One objective of this study will be to develop a new concept for monitoring trace contaminants in a spacecraft atmosphere. An initial evaluation will be performed on monitoring techniques to assess their capabilities, limitations, and applications. Based on these results, an instrument will be selected for further test development. If possible, a commercial instrument will be selected and modified to incorporate flight characteristics. The instrument will then be tested individually and integrated into an existing ECLSS subsystem for system tests.

W90-70106 **(51) 506-49**
Goddard Space Flight Center, Greenbelt, MD.
SYSTEMS ANALYSIS
William T. Tumulty 301-286-6185

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 (EOS) 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. These studies will utilize science requirements and Global Change Technology Workshops data bases that have been established during this past year in conjunction with ongoing Goddard EOS Project activities. The first NASA Polar Orbiting Platform (N-POP1) will establish the initial technology baseline for the space segment from which the studies will derive evolutionary elements of the infrastructure supporting fully matured Mission to Planet Earth scenarios. In addition, the Project EOS Data/Information System (EOSDIS) will form the architectural baseline for the initial and evolutionary end-to-end information system.

W90-70107 **(21) 506-49**
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
M. G. Shafto 415-694-6170

The objective of this RTOP is to identify the new technology

requirements in detectors and associated optics necessary for the remote sensing estimation of plant biochemical composition. The approach will be to convene a workshop of industrial, university, and national laboratory (including NASA) scientists in biophysics, biochemistry, optics, material science, physics, and remote sensing/spectroscopy to discuss and recommend a research program and priorities. A short document making clear problem statements and potential research and development approaches will be produced. research, and provides an overview for management and a guide for researchers. A workshop will be held to bring together key researchers in aerospace bionics to identify and prioritize research opportunities.

W90-70108 **(23) 506-49**
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
W. R. Hook 804-864-6055

The technical objectives of this research are to identify technology requirements for advanced space systems and 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.

W90-70109 **(22) 506-49**
Lewis Research Center, Cleveland, OH.
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 novel chemical and 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. 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 and Propulsion Systems and 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 advanced technologies with strong benefits and required in-space technology development.

W90-70110 **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, TX.
SYSTEMS ANALYSIS
Kyle Fairchild 713-283-5380

The objective of this RTOP is to investigate technology options for Space Station Freedom (SSF) evolution and the use of SSF as a technology development testbed. FY-90 activities are grouped into three tasks. Task 1 investigates the man-machine interface requirements needed in an increasingly complex multi-task environment. Task 2 investigates the applicability of neural networks within the SSF operating systems, both for continued use on SSF and as a development and demonstration testbed for application to other space-based and planetary systems. Task 3 assesses the feasibility and benefits of an advanced ECLS testbed aboard SSF, to determine long-term microgravity effects and overall systems reliability and validation of an advanced space-based ECLS system.

W90-70111 **(55) 506-49**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEMS ANALYSIS
Robert Kelley 818-354-9330

The objectives are to identify critical technology needs for future high priority NASA missions and assist in the formulation of the necessary supporting technology development programs. Studies will continue to contribute to planning for the Global Change Technology Initiative and will evaluate the technology needs of optical interferometry and deep space exploration missions. 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.

W90-70112 **(10) 506-49**
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Lana M. Couch 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 research and technology. 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 research and technology.

University Space Research

W90-70113 **(10) 506-50**
National Aeronautics and Space Administration, Washington, DC.
UNIVERSITY SPACE ENGINEERING RESEARCH
Lana M. Couch 202-453-2737

The objective of the university space engineering research program 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 the decline in the availability of qualified space engineers by making a long-term commitment to universities. The program elements include the university space engineering research centers, supporting interdisciplinary research; the university investigator research program, providing grants to individuals with outstanding credentials; and the university advanced design program, which funds advanced systems study courses at the senior and graduate levels.

Interdisciplinary Technology

W90-70114 **(10) 506-90**
National Aeronautics and Space Administration, Washington, DC.

INTERDISCIPLINARY TECHNOLOGY
Edna Templeton 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.

In-Space Experiments Technology

In-Space Experiments Technology

W90-70115 **(22) 589-01**
Lewis Research Center, Cleveland, OH.
IN-SPACE EXPERIMENTS
W. J. Masica 216-433-2864
(506-48-00)

The In-Space Technology Experiments Program supports definition and development of in-space technology experiments to flight evaluation and validation of advanced technologies for future space systems. There are two program elements in this submittal: NASA Space Technology Experiments and Industry/University Experiments. The NASA Space Technology Experiments address advanced space technologies being developed at LeRC. Some of the experiments may be developed and conducted in cooperation with international partners or other Government agencies. The Industry/University (I/U) Experiments address the technologies conceived and developed under industry independent research and development. Lewis Research Center manages NASA and I/U flight projects in two Technology Themes: Power Systems, and Propulsion and Propellant Management. Included are four NASA flight projects: SAMPIE (Solar Array Module Plasma Interaction Experiment), TEST (Thermal Energy Storage Technology), the Arcjet Flight Test and IAPS (Ion Auxiliary Propulsion System); and one I/U flight project: the Boeing Tank Pressure Control Experiment.

W90-70116 **(51) 589-01**
Goddard Space Flight Center, Greenbelt, MD.
IN-SPACE EXPERIMENTS
Roy McIntosh 301-286-3478

The objective of this RTOP is to develop NASA space technology and industry/university flight experiments, which require access to space, to investigate critical technology needs. Integration support for these experiments will also be provided as part of this RTOP. The program currently includes experiments dealing with thermal management, fluid dynamics, contamination modelling and measurements, and degradation of X-ray optics due to the effects of atomic oxygen. The experiments will be flown on the NASA Space Shuttle as get away specials, on hitchhiker carriers and in the mid deck lockers of the Shuttle. The information gathered from these experiments will benefit a broad class of future NASA, DOD, and private sector missions.

W90-70117 **(23) 589-01**
Langley Research Center, Hampton, VA.
IN-SPACE EXPERIMENTS
W. R. Hook 804-864-6055
(506-48-00)

The technical objectives of this program are to conduct the development of the Mid-Deck O-Gravity Dynamics Experiment (MODE), and to carry out breadboard studies and design activities for the Stanford University/NASA Lidar In-Space Technology Experiment (SUNLITE). A contracted effort will be conducted to develop the hardware and associated procedures for performing MODE. In-house and contracted studies will be directed at a breadboard of critical components of SUNLITE and the development of a laser assembly specification.

W90-70118 **(62) 589-01**
Marshall Space Flight Center, Huntsville, AL.
IN-SPACE EXPERIMENTS
Byron J. Schrick 205-544-1976

The overall objective of this experiment is to obtain an engineering and environmental assessment of the performance capabilities of emulsion chamber techniques in space. To accomplish this the following goals have been established: (1) Design, fabricate, and fly on the STS an emulsion chamber of the general type which will be a likely candidate for cosmic ray and high energy physics studies on the space station; (2) Assess the radiation background encountered in such detectors in orbits up to 400 km; (3) Assess pre- and post-flight environmental effects on passive detectors; and (4) Assess the effects of large shielding on dose in space station orbits. In order to achieve flight manifestation, Marshall Space Flight Center (MSFC) is responsible for total management of the emulsion chamber technology (ECT) experiment. The University of Alabama at Huntsville (UAH) will be awarded the contract to design and fabricate the flight emulsion chamber box subsequent to NASA Headquarters Peer Review Team approval.

W90-70119 **(72) 589-01**
Lyndon B. Johnson Space Center, Houston, TX.
IN-SPACE EXPERIMENTS
Keith E. Henderson 713-283-5307

Debris in low earth orbit (LEO) constitutes an increasing hazard to manned and unmanned spacecraft and astronauts on EVA. For Space Station, relatively large debris pieces consititutes the most serious threat while smaller pieces threaten astronauts on EVA. A Shuttle payload bay experiment consisting of a telescope equipped with visible and thermal infrared cameras is proposed to sample the existing LEO debris environment for objects greater than or equal to 1 millimeter diameter. Data can be used in the preparation of a Space Station collision warning system as well as to extend and update existing models of the debris environment. The experimental Investigations of Spacecraft Glow (EISG) objectives are to study and characterize glow emissions in the ultraviolet visible and infrared wavelengths and determine how these emissions vary with orbital altitude and spacecraft surface temperature. A pallet-based set of instruments will be designed and developed to provide data leading to an improved understanding of the mechanisms, processes, and molecular transition states responsible for glow. This will enable the development of methods and procedures to limit the undesired effects of glow on sensitive scientific experiments conducted during future NASA missions.

Civil Space Technology Initiative (CSTI) Program

Operations

W90-70120 **(72) 590-11**
Lyndon B. Johnson Space Center, Houston, TX.
TELEROBOTICS
G. J. Reuter 713-483-1520

The objective of the applications program element 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 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 to provide a high correlation between simulated and on-orbit manipulator dynamics. The objective of the mechanisms program element is to perform research in advanced robotics regarding mechanisms, real time computation, fault tolerant architecture, adaptive control, and metrology. The primary goal is to develop an advanced precision, dexterous, 8 DOF carbon fiber manipulator that will be modular and layered. Research to be performed includes advanced actuator development, dual arm control for assembly, universal manual controller development, and metrology of manipulators. An additional goal is to develop a three string fault tolerant architecture for redundant motor manipulator systems that will satisfy reliability requirements of no single point failures and provide a failsafe/fail op capability.

W90-70121 **(10) 590-11**
National Aeronautics and Space Administration, Washington, DC.
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 an expert system for task assignment and housekeeping aboard a space station. This work will be carried out under a grant to MIT. A second task is the development of exoskeleton teleoperator technology which will be done via a Memorandum of Understanding with the U.S. Air Force (Wright-Patterson AFB). A third task is to provide support to the automation and robotics program.

W90-70122 **(51) 590-11**
Goddard Space Flight Center, Greenbelt, MD.
TELEROBOTICS
Henry H. Plotkin 301-286-6185

The overall RTOP objective is to develop and demonstrate technologies to achieve autonomous robotic servicing in space. The Goddard Space Flight Center (GSFC) robotics research and technology program is developing flight robotics on a two pronged technology front: system applications evaluation and mechanisms research. The application effort is creating autonomous systems capable of generating their own plans for disassembly, assembly, servicing and maintenance of complex space platforms using computer aided design (CAD) derived geometric knowledge-bases and spatial reasoning. The mechanism effort is developing basic physical conceptual designs for robotic manipulation, specifically: motor, actuator, and controller design; end effector concepts; joint compliance in zero gravity; electromechanical joint architectures; and optimization techniques. GSFC will use an evolutionary approach which progresses from technology development to flight hardware in a pragmatically phased program which will put Code R technology products into space quickly by leveraging existing capabilities and technology from other programs (FTS, Flight VAX Experiment, EOS MODIS-T, Hubble Space Telescope, Get Away Special, Hitchhiker) other Centers (JPL, Ames, LaRC, JSC), and other agencies (NRL, Stanford, U.S. Naval Academy, and Cath. Univ.).

W90-70123 **(21) 590-11**
Ames Research Center, Moffett Field, CA.
TELEROBOTICS
Henry Lum, Jr. 415-694-6544
(590-12-00)

The objective is to develop and test integrated knowledge-based systems including real-time control and human/machine interfaces for free-flying, intelligent space robotic systems 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 and task planning for mobile, cooperating, 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, DOD, NSF, and industry. Current research elements include: autonomous navigation and task level control of satellite robots; real-time control of cooperating arms and cooperating mobile robots; and object manipulation and assembly strategies. A research effort has also been established with Stanford University's Department of Computer Science to integrate the Artificial Intelligence research with the robotics research with emphasis on the development of intelligent cooperating robots.

W90-70124 **(62) 590-11**
Marshall Space Flight Center, Huntsville, AL.
TELEROBOTICS
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 telerobotic systems and demonstrations using scaled test tasks and quantitative measurements. The effort has developed sensored task simulator with graduated difficulty and quantitative measurements of position, force, and torque 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. To implement autonomous guidance several areas must be researched and integrated: guidance algorithms, sensor(s), and target(s). The guidance algorithms for docking a vehicle autonomously with a target have been and are continuing to be developed under the Pathfinder program, so the tasks in this RTOP are in two areas: (1) sensor research and development; and (2) target configuration. The results of this development will be tested in hardware through a variety of scenarios and lighting conditions.

W90-70125 **(23) 590-11**
Langley Research Center, Hampton, VA.
TELEROBOTICS
J. F. Creedon 804-864-6033

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 conceptualize, 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.

W90-70126 **(76) 590-11**
John F. Kennedy Space Center, Cocoa Beach, FL.
TELEROBOTICS
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 six 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 Applications 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 algorithms 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 culminates in a realistic high-fidelity applications demonstration of a 6-DOF remote umbilical mate/demate.

W90-70127 **(55) 590-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TELEROBOTICS
John F. Stocky 818-354-6499
(506-44-00)

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, platform maintenance and repair, and support of scientific experiment. 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 with 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.

W90-70128 **(55) 590-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARTIFICIAL INTELLIGENCE
Dave Atkinson 818-354-6476
(656-43-02; 656-65-05)

The objectives of this task are twofold: (1) To apply and extend mature AI-based solutions in the areas of monitoring, diagnosis and data analysis, and demonstrate technological readiness for addressing current mission operations and scientific data analysis needs. (2) To push the state-of-the-art in AI in planning and model-based reasoning to address long-term JPL and NASA needs. The task is multi-year and is divided into one continuing element Ground Data Systems Automation, which will demonstrate a multi-mission, multi-subsystem monitoring and diagnosis capability, and three new elements: Planner Evaluation Techniques, which will produce a framework for classifying planning problems and solutions; Selective Processing in Monitoring, which will generate and evaluate methods for monitoring systems where complexity and resource limitations preclude exhaustive verification; and Scientific Analysis Assistant, which will use AI techniques to unify scientific data access, management, analysis, and visualization capabilities in a single automated workstation.

W90-70129 **(21) 590-12**
Ames Research Center, Moffett Field, CA.
ARTIFICIAL INTELLIGENCE
Henry Lum, Jr. 415-694-6544
(591-11-00; 591-12-00; 488-51-00)

The objective of the artificial intelligence research program is to develop, integrate, and demonstrate the science and technology of AI that will lead to increasing the operational capability, safety, cost effectiveness, and probability of success of NASA missions. The research will enable humans to interact with machines at increasingly higher levels of goals and with increasing trust in the ability of the machine to react to unforseen circumstances. The approach of the ARC program has been to develop a world-class internal laboratory in collaboration with an academic/industrial team of leading scientists and engineers. The program includes basic research in machine learning, planning and scheduling, intelligent agents, and large-scale knowledge-based systems. It also encompasses specific applications projects in the area of intelligent assistants to human problem-solving as well as many applications spinoffs from the basic research tasks. In addition, several full-scale brassboards for an advanced, symbolic/numeric parallel processing architecture will be constructed under the program. Finally, all of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly DARPA's Information Sciences Technology Office (ISTO).

W90-70130 **(51) 590-12**
Goddard Space Flight Center, Greenbelt, MD.
ARTIFICIAL INTELLIGENCE
John T. Dalton 301-286-8623

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.

W90-70131 **(76) 590-12**
John F. Kennedy Space Center, Cocoa Beach, FL.
ARTIFICIAL INTELLIGENCE
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 and object-based structure. During 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.

W90-70132 **(22) 590-12**
Lewis Research Center, Cleveland, OH.
ARTIFICIAL INTELLIGENCE
H. W. Brandhorst 216-433-6149
(488-51-00)

The objective of this RTOP is to provide technology development support for application of knowledge based systems (KBS) to the Space Station Freedom Electrical Power System (SSFEPS). This objective specifically includes: (1) development/application of appropriate KBS architectures to the SSFEPS; (2) development/adaption of KBS tools to the SSFEPS;

and (3) investigation of cooperative problem solving considerations between knowledge based power systems and other intelligent agents. An additional objective is to resolve issues involved in application/transfer of autonomous power systems technology from the SSFEPS to other large complex aerospace electrical power systems. The approach is to develop an Automated Power Expert (APEX) system, consisting of fault management and power/energy scheduler software along with appropriate control interfaces, and demonstrate its operation on the LeRC Space Station EPS testbed facility. This is a cooperative program between OAST Code RC and OSS Code ST (488-51-03). The Code RC emphasis is on development/application of KBS software/tools, while the Code ST is on support for testbed/control system interfacing and SS global integration considerations.

W90-70133 **(72) 590-12**
Lyndon B. Johnson Space Center, Houston, TX.
ARTIFICIAL INTELLIGENCE
Kathleen J. Healey 713-483-4776

The objectives of this RTOP are to continue the appropriate application of artificial intelligence in ground operations centers, to demonstrate the feasibility and use of cooperative expert systems for performing on-board functions such as might be encountered on advanced space vehicles, and to define a context for design guidelines for human interfaces with intelligent systems, specifically in the domain of fault management. The approach is to continue the INCO approach in the Shuttle Mission Control Center and to expand the paradigm to the Orbital Maneuvering Vehicle Control Station, introducing video data as input to the expert systems for the first time. In the area of cooperative expert systems, the current state-of-the-art will be codified, the desirable degree of cooperation and an appropriate architecture will be characterized, and multiple prototypes will be developed/demonstrated. The context for design guidelines for human interface will be defined by involving universities in NASA application case studies, studying cases from aerospace and nuclear domains, studying the applicability of current research and guidelines, and prototyping multiple interfaces for evaluation.

W90-70134 **(62) 590-12**
Marshall Space Flight Center, Huntsville, AL.
ARTIFICIAL INTELLIGENCE
J. B. Haussler 205-544-1762

This effort consists of two tasks: Hubble Space Telescope Design/Engineering Knowledge base (HSTDEK) and SSM/PMAD cooperative Expert System Application. 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 relative to the projects. 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. The SSM/PMAD Task consists of three expert systems that must cooperate to control a single subsystem. Somehow, these expert systems must understand each other well enough to work together in solving problems while avoiding stalemate conditions. The objective of this task is to make one or more of the expert systems smart enough to understand how to interact with the others. This may be accomplished, at least in part, with smart front ends and interfaces. A blackboard architecture could be implemented as one approach to this problem. A related issue to multiple interactive expert systems is that of expert systems closely interacting with conventional software. NASA programs involving artificial intelligence will, in many cases, require the expert system(s) to be closely coupled to embedded conventional software programs.

W90-70135 **(22) 590-13**
Lewis Research Center, Cleveland, OH.
HIGH CAPACITY POWER
H. W. Brandhorst 216-433-6149
(586-01-00)

The NASA CSTI High Capacity Power Program is intended to augment the GES 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.

W90-70136 **(55) 590-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH CAPACITY POWER
Kenneth L. Atkins 818-354-6293

The objective is to develop and demonstrate solid-state thermal-to-electric power conversion technology that meets the long lifetime (10 Yr), high efficiency (10 percent or greater) requirements of future high capacity space power systems. The eventual goal is high power density systems that meet mission requirements and minimize system mass, particularly for SP-100 type systems. Specifically, high efficiency thermoelectric materials based on silicon-germanium type semiconductor materials will be developed. The approach includes industry and university tasks to achieve demonstration elements with strong analytical support. The major activities focus on doping techniques with silicon-germanium materials utilizing both polycrystalline and single crystal approaches, coupled with theoretical modeling.

W90-70137 **(55) 590-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF FLEXIBLE STRUCTURES
W. E. Layman 818-354-3023

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 is part of a comprehensive NASA-wide CSI research program which is concentrated 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 is participating 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 CSI technology development on micro-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. The design methods, models and system concepts will be validated through ground testing. Flight tests will be proposed for those essential elements that require the on-orbit environment.

W90-70138 **(62) 590-14**
Marshall Space Flight Center, Huntsville, AL.
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 Astrophysics 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) will be

implemented in FY-90. 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.

W90-70139 **(23) 590-14**
Langley Research Center, Hampton, VA.
CONTROL OF FLEXIBLE STRUCTURES
J. F. Creedon 804-864-6033

The overall objective of the 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 21st-century NASA missions. Long-term goals of the effort are as follows: (1) To provide spacecraft dynamic response amplitude reductions of 50 percent, for any input or maneuver, with minimum increase in system mass; (2) To enable the use of wide-bandwidth CSI control systems to achieve several orders of magnitude improvement in control and pointing capabilities; (3) To predict the on-orbit performance of CSI systems within 10 percent of all amplitude, frequency, time, and stability requirements based on the results of integrated analyses tuned/corrected by closed-loop ground and/or flight test data; (4) To develop unified controls-structures modeling, analysis, and design methods which allow a complete iteration on all critical design variables in a single integrated computational framework; and (5) To develop the capability to validate the performance of flight systems by analysis and ground tests.

Transportation

W90-70140 **(22) 590-21**
Lewis Research Center, Cleveland, OH.
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 attention 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.

W90-70141 **(62) 590-21**
Marshall Space Flight Center, Huntsville, AL.
EARTH-TO-ORBIT
J. L. Moses 205-544-1747

The objective of this RTOP is to extend and further develop the earth-to-orbit propulsion technology base in support of current and future space transportation systems. 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, and controls and monitoring subsystems. The technology advancements arising 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.

Science

W90-70142 **(22) 590-31**
Lewis Research Center, Cleveland, OH.
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, with an expected frequency tuning range (by voltage tuning) of approximately + or - 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.

W90-70143 **(51) 590-31**
Goddard Space Flight Center, Greenbelt, MD.
SCIENCE SENSOR TECHNOLOGY
Henry H. Plotkin 301-286-6185

Sensor technology required for important future space science and applications missions is being developed and validated in three areas: laser local oscillators and photoconductive mixers for spaceborne heterodyne spectrometers at infrared and submillimeter wavelengths from 30 to 200 micrometers will enable future evolution of science missions such as Comet Rendezvous and Asteroid Flyby (CRAF)-Cassini, Galileo, Large Deployable Reflector, SOFIA airborne astronomy, Shuttle and Space Station attached experiments, etc. Components for spaceborne laser ranging and lidar applications are being developed for a number of earth science instruments such as those to be flown on Earth Observing System (EOS). These include picosecond pulse lasers and receivers for Geodynamic Laser Ranging Systems and tunable lasers for atmospheric constituent and meteorology studies. Finally, long-life, vibration-free, efficient cryogenic cooler systems are being developed to meet requirements of a number of new sensing instruments which must operate at temperatures ranging from 65 K to as low as 2 K. Tasks include flexure and magnetic bearings, multistage coolers, and new concepts for efficient regenerative cycles.

W90-70144 **(21) 590-31**
Ames Research Center, Moffett Field, CA.
CSTI - 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.

W90-70145 **(23) 590-31**
Langley Research Center, Hampton, VA.
SCIENCE SENSOR TECHNOLOGY
Frank Allario 804-864-6027

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.

W90-70146 **(62) 590-31**
Marshall Space Flight Center, Huntsville, AL.
SCIENCE SENSOR TECHNOLOGY
J. B. Haussler 205-544-1762

The objective of this effort is to conduct CO2 laser research for space-based lidar application. The planned approach incorporates both in-house and contractual efforts to arrive at the desired objectives.

W90-70147 **(55) 590-31**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE SENSOR TECHNOLOGY
Virendra Sarohia 818-354-6758

This task develops new sensor technologies for future NASA mission needs. Emphasis is on infrared direct detection (3 to 300 micrometer), submillimeter heterodynedetection (100 to 1000 micrometer) and on sensor coolers. Three detector subelements are: (1) improve quantum efficiency and response of Schottky-based and quantum and well IR detectors; (2) develop far-infrared (FIR) focal plane arrays in the 30 to 300 micrometer range using Ge Blocked Impurity Band (BIB) detectors that are radiation hard and compatible with existing Si multiplexer technology; and (3) develop advanced semiconductor laser and laser arrays in 1.6 to 2.1 micrometer range. The goal of the submillimeter heterodyne task is to develop space qualifiable receivers for the range of 300 to 3000 GHz. The local oscillator development is to demonstrate a solid state multiplier source with 100 microwatt at greater than 400 GHz. The mixer effort focuses on Superconductor-Insulator-Superconductor (SIS) tunnel junctions for heterodyne receiver arrays. The antenna array element is to develop mixers for use with NbN SIS junctions. Cooler suitable for cooling detectors in the range from sub-Kelvin to 140 K would be developed. One subelement is to develop low-vibration, low-EMI sorption refrigerators for 65 to 140 K. A second is directed at experiments on unique, high-leverage coolers in the sub-Kelvin to 20 K range. The third is to develop generic cooler vibration and EMI test facilities.

W90-70148 **(55) 590-32**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA: HIGH RATE/CAPACITY
Daniel E. Erickson 818-354-1656
(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. This RTOP is part of the CSTI Data Systems: High Rate/Capacity Program and will be managed in accordance with the OAST program plan and the JPL project plan for this program. Data system technology development included in this RTOP will both enhance the ability to make 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 spaceborne processor capable of radiometric calibration, compression, and simple information extraction as applied to imaging spectrometer data; and (3) an autocorrelation spectrometer suitable for use in spaceborne millimeter-wave and submillimeter-wave radiometers. In these tasks 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. An additional task will analyze and research on-board data storage technologies.

W90-70149 **(51) 590-32**
Goddard Space Flight Center, Greenbelt, MD.
DATA: HIGH RATE/CAPACITY
John T. Dalton 301-286-8623

An onboard high rate/high capacity data system called the Configurable High Rate Processing System (CHRPS) suitable for onboard spacecraft processing of space and earth sciences sensor data will be developed. CHRPS capabilities will be adaptable to the needs of different instruments and missions by reconfigurating 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. CHRPS 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 Mbps. The integration of technology components from other centers in the Clearinghouse for Scientific and Technical Information (CSTI) Data Systems Program into a testbed demonstration will be part of this RTOP.

W90-70150 **(23) 590-32**
Langley Research Center, Hampton, VA.
DATA: HIGH RATE/CAPACITY
Frank Allario 804-864-6027
(506-45-00)

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 and analysis, together with new device and systems technologies in high-speed, space qualified processors, and high rate/capacity optical storage systems, 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, and Fiber Optic Integrated Circuit Transceivers.

W90-70151 **(23) 590-33**
Langley Research Center, Hampton, VA.
PRECISION SEGMENTED REFLECTORS
C. P. Blankenship 804-864-6005

The research includes development, fabrication, and testing

programs in structures and materials with emphasis on: (1) advanced composite materials and coatings, 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.

W90-70152 **(55) 590-33**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRECISION SEGMENTED REFLECTORS
Eugene Pawlik 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 approx. greater than 75 micrometer) 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 accurate figure, and test these panels on a representative structure. Technology will be validated in a test-bed demonstration of an actively controlled, segmented reflector in 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 orbital thermal stability, long term stability, and fabrication methods to extend the panel size. Vibration damping techniques will be developed for the panel support structure.

Pathfinder Program

Surface Exploration

W90-70153 **(55) 591-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PATHFINDER PLANETARY ROVER (PPR)
Roger Bedard 818-354-4238
(591-12-00)

The overall goal of the Pathfinder Planetary Rover (PPR) Program is to develop, integrate and validate technology to enable the automated and piloted exploration of extensive areas of lunar and planetary surfaces. In FY-90, as it was in FY-89, the program will be focused on unmanned rover technologies such as navigation, mobility, power, operations/autonomy, computation, thermal control and communications with the emphasis of the program on semi-autonomous navigation. 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 related; the manned rover program element will be built upon the technology base developed in the earlier unmanned rover program elements.

W90-70154 **(21) 591-11**
Ames Research Center, Moffett Field, CA.
PLANETARY ROVER
Keith Swanson 415-694-4383
(591-12-00; 590-12-00)

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). An additional task includes the development of technology for rover-based construction of large antenna arrays as potentially applicable to far-side Lunar arrays.

W90-70155 **(10) 591-11**
National Aeronautics and Space Administration, Washington, DC.
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 will focus on the development of algorithmic solutions to permit mobility of a legged vehicle, and the implementation of these algorithms on the rover testbed. This work will be carried out under a grant to Carnegie Mellon University.

W90-70156 **(22) 591-11**
Lewis Research Center, Cleveland, OH.
PLANETARY ROVER
H. W. Brandhorst 216-433-6149

The objective of the program is to focus the development of power system technologies to a level of readiness sufficient to enable and enhance extraterrestrial rovers. Toward this end, technologies compatible with the varied rover missions will be chosen based on performance predictions matching needs followed by verified performance of key technology components. The program will include power subsystem analysis defining technology requirements and guiding subsequent development. Several candidate technology activities will be pursued which offer the best choices for various rover concepts while maintaining the availability of options. These include low mass, high efficiency photovoltaic cells; low mass, high discharge rate batteries; high power density regenerative fuel cells; and dynamic isotope power systems.

W90-70157 **(62) 591-11**
Marshall Space Flight Center, Huntsville, AL.
PLANETARY ROVER
J. B. Haussler 205-544-1762

The objectives of this task are to identify and define areas of technology needed for a piloted planetary rover, to assess the state-of-the-art in these areas, and to investigate those areas where technology development is required. The approach includes both in-house and contracted efforts.

W90-70158 **(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 the surface and near-subsurface of planets, moons and small bodies. 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 broad range of missions. 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 design will be developed. This activity will be performed in cooperation with the Planetary Rover element of Pathfinder. SAAP technologies will be integrated into an evolving series of testbeds leading to the demonstration a fully operational technology base. The technical approach includes: (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 the SAAP testbed.

W90-70159 **(21) 591-12**
Ames Research Center, Moffett Field, CA.
SAMPLE ACQUISITION ANALYSIS AND PRESERVATION
D. Thompson 415-694-4383
(591-11-00; 590-12-00)

This activity is focused on developing software for autonomous recognition of geologic features which are used in science decision processes concerning where or what to sample, what is the local geologic setting, and what science can be done remotely without sampling. The task exploits the capabilities of a vision lineation recognition system developed at SRI International and fuses feature data with multispectral data to determine textural, structural, and compositional clues in a planetary geologic setting.

W90-70160 **(72) 591-12**
Lyndon B. Johnson Space Center, Houston, TX.
SAMPLE ACQUISITION, ANALYSIS, AND PRESERVATION
D. 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 test drilling tools applicable to the Mars environment and anticipated Mars samples. Bench top testing will establish the optimum range of performance factor for a variety of designs. A strawman concept will be generated for the containerization and preservation system. The integrity and leak tightness of selected candidate containers will be tested on a limited basis. The operational efficiency will be used as a metric for optimization of the system concept. Instrumentation technology will be developed for the on-surface analysis of samples. Areas of concentration will include differential calorimetry, gas analysis by chromatography and/or mass spectrometry, and mineral and compositional analysis using X-ray methods. Emphasis will be given to concepts for autonomous sample loading and purging. Operational (time) efficiency will be assessed for the operation of candidate analysis instruments.

W90-70161 **(72) 591-13**
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS LANDER
Kenneth Baker 713-483-2041

The objective of this work is to develop, for use in the Mars Rover Sample Return (MRSR), Lunar Outpost and Manned Mars Exploration 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 10.0 killometer and surviving rocks up to 1.0 meter in size and slopes up to 15 degrees over a baseline of 10 meter. 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.

W90-70162 **(21) 591-13**
Ames Research Center, Moffett Field, CA.
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.

W90-70163 **(55) 591-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMOUS LANDING
Allan R. Klumpp 818-354-3892

System integration, planetary terrain modeling constitute the first element. The aim is to develop technology to enable modeling planetary terrain in preparation for soft landing. It must be possible to: (1) construct the terrain model using statistics regarding the distribution of landing hazards, and (2) use the terrain model in simulated landings to test hazard detection and avoidance. Element 2 consists of precision landing and terrain following navigation. The aim 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 site.

W90-70164 **(22) 591-14**
Lewis Research Center, Cleveland, OH.
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; will address energy storage technology using hydrogen/oxygen regenerative fuel cells with increased life and reliability; will develop amorphous silicon photovoltaic technology with increased efficiency, reduced mass and improved lifetime and reliability; and will 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

W90-70165 **(62) 591-21**
Marshall Space Flight Center, Huntsville, AL.
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.

W90-70166 **(21) 591-21**
Ames Research Center, Moffett Field, CA.
AUTONOMOUS RENDEZVOUS AND DOCKING
E. Ochoa 415-694-6725

The objective is to develop and understand a neural network simulation for automated control of docking. Information about sensor inputs and constraints on object motion will be used to construct a neural network whose output is the thruster commands to guide one spaceborne object into a docking configuration with a second spaceborne object. Neural network techniques are being examined because they may provide solutions to previously unsolvable or difficult-to-solve nonlinear control problems. In addition, the solutions can be obtained much more rapidly than with conventional control methods, and should enable real-time behavior. The research will be performed by both Ames personnel in the Intelligent Systems Technology Branch and researchers at Stanford University. The system will be developed to be compatible with the flat floor facility at Marshall Space Flight Center for eventual test and demonstration there.

W90-70167 **(55) 591-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMOUS RENDEZVOUS AND DOCKING
Allan R. Klumpp 818-354-3892

The aim is to develop autonomous rendezvous guidance techniques applicable to transfers between circular, elliptical, parabolic, and hyperbolic trajectories that are suitable for implementation in flight computers. The guidance techniques will make possible rendezvous that are highly efficient (in terms of propellant and computation) during planetary ascent, on return to earth, and between low-earth orbit and geosynchronous orbit.

W90-70168 **(72) 591-21**
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS RENDEZVOUS AND DOCKING
S. L. Lamkin 000-000-0000

This RTOP will develop, validate, and demonstrate autonomous rendezvous and docking (AR and D) capability to support manned and unmanned vehicle operations in earth, 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 be 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.

W90-70169 **(72) 591-22**
Lyndon B. Johnson Space Center, Houston, TX.
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. During the period of this RTOP the construction language interface to the computer will be developed. Also, fabrication of the heat shield components will be completed.

W90-70170 **(55) 591-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IN-SPACE ASSEMBLY AND CONSTRUCTION
Ben K. Wada 818-354-3600

The long range objective of this program is to identify, develop and validate in-space assembly and construction technologies for large complex structures 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 is to participate as part of the NASA-wide team headed by LaRC to help plan and focus the effort and to develop construction concepts to move large and/or massive subsystems for assembly or precisely locate smaller subsystems for construction. The approach is to initially focus on space crane structure/control concept necessary to meet the requirements established by the NASA-wide team and to validate the concepts through analyses and tests. Subsequently with the growth in the program, the JPL role will include developments in ground test methods and deployable utilities.

W90-70171 **(62) 591-22**
Marshall Space Flight Center, Huntsville, AL.
IN-SPACE ASSEMBLY AND CONSTRUCTION
R. W. Schock 205-544-4060

The objectives of this technology program are: (1) 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. (2) Develop concepts for fixtures to support 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.

W90-70172 **(23) 591-22**
Langley Research Center, Hampton, VA.
IN-SPACE ASSEMBLY AND CONSTRUCTION
C. P. Blankenship 804-864-6005

The research includes technology development for in-space assembly and construction of large spacecraft envisioned for future space missions. The spacecraft 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 methods that combine efficiency and autonomy with reliability, economy, and ease of operation and maintenance. Research will be conducted to develop concepts and methodologies for on-orbit construction of large spacecraft in space with emphasis on design-for-construction; to develop infrastructures and hardware concepts; and to demonstrate the technology with a ground based testbed.

W90-70173 **(22) 591-23**
Lewis Research Center, Cleveland, OH.
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.

Humans-In-Space

W90-70174 **(72) 591-31**
Lyndon B. Johnson Space Center, Houston, TX.
EXTRAVEHICULAR ACTIVITY/SUIT TECHNOLOGY
A. F. Behrend 713-483-9241

The objectives of this RTOP effort are to continue the development of the analytical and hardware technologies necessary to allow humans to perform extravehicular activities (EVAs) productively and efficiently in the hostile environments of the Moon and Mars. This initial effort will concentrate on five technology areas: (1) human requirements definition, emphasizing human factors; (2) EVA systems integration modeling and trade studies; (3) thermal control, emphasizing heat rejection; (4) atmosphere control subsystem modeling; and (5) pressure suit technology, emphasizing suit materials and structures. The research in all of these areas will encompass the gathering of fundamental process data necessary to develop the analytical models required for the conduct of supporting trade studies and system analyses.

W90-70175 **(21) 591-31**
Ames Research Center, Moffett Field, CA.
EXTRAVEHICULAR ACTIVITY/SUIT
Bruce W. Webbon 415-694-6646
(591-32-00; 591-34-00)

Astronauts on Lunar and planetary missions will explore and collect samples, assemble, repair and service their habitat and other equipment, and carry out experiments and studies removed from the immediate confines of their vehicle or base. These activities will require an Extravehicular Activity (EVA) work system consisting of a pressure suit, life support system, and ancillary equipment which will allow them to work comfortably, efficiently, and safely. The EVA system must be rugged, reliable, and impervious to dust and other environmental hazards. It must also be easily serviced and maintained and require minimal resources to keep it in service. This program will develop the EVA work systems technology to allow such missions to be performed by developing advanced pressure suits, life support systems, and other items of EVA equipment and interfaces with other systems such as robotic assistants.

W90-70176 **(21) 591-32**
Ames Research Center, Moffett Field, CA.
SPACE HUMAN FACTORS
M. G. Shafto 415-694-6170

The Pathfinder Space Human Factors program will enable productive and safe human performance throughout and after long duration space flight and lunar/planetary missions, based on scientific understanding and selected demonstration of human capabilities, limitations, and adaptive changes. The objectives of the program are to enable, enhance, and extend the human's unique capabilities and thereby to significantly increase the benefit from long duration space missions; to develop the requirements for human-machine compatibility and provide significant improvements in the capability to incorporate such requirements in manned space systems; to determine the performance requirements for systems of humans, automation and robotics and for allocating functions to humans and systems to meet these requirements; and to provide methods and techniques to meet human safety and performance requirements. The technical approach will be to characterize relevant operational experience, to work closely with appropriate operational experts, to coordinate work with researchers in allied disciplines in order to leverage related research, and to conduct research and development focussed on human performance models and databases, computer-aided design tools, advanced automation interfaces which enhance human capabilities, crew support systems, and human-automation-robotic systems.

W90-70177 **(72) 591-32**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE HUMAN FACTORS TECHNOLOGY
Barbara J. Woolford 713-483-3701

This RTOP is designed to provide technologies in human factors that support future long-term space exploration missions. Research activities will be carried out in two areas: models, data and tools; and crew support. The first consists of efforts to quantitatively and qualitatively predict human performance, both physical and mental, in extended zero-g and surface partial-g. These efforts include computer modeling, developing conceptual models and abstracting lessons learned from previous lunar spaceflight experience. The models, data, and information collected will be disseminated through an intercenter workshop. To develop models, it is necessary to collect data on performance parameters. Two facilities, the Anthropometry and Biomechanics Lab and the Human-Computer Interaction Lab, are used for this purpose. Under crew support, studies are being conducted to analyze and predict crew-spacecraft interface technologies with initial emphasis on computer interfaces. A study of the significant problem of technology to support consumables for long range missions such as Mars exploration will be conducted.

W90-70178 **(72) 591-34**
Lyndon B. Johnson Space Center, Houston, TX.
PHYSICAL/CHEMICAL LIFE SUPPORT TECHNOLOGY
A. F. Behrend 713-483-9241

The objectives of this RTOP effort are to provide the technology base required to sustain human life throughout long-duration space missions that will explore the solar system. The technical approach is based on a dual-path strategy which combines process, subsystem and system-level computer modeling and analysis with fundamental laboratory research, development, and testing activities. This approach will be applied to select and develop technology candidates for use in primary life support subsystems

for air revitalization, water management, and thermal control. Subsystem/system-level analyses and assessments will be performed to assist in guiding and directing the overall effort.

W90-70179 **(21) 591-34**
Ames Research Center, Moffett Field, CA.
PHYSICAL CHEMICAL LIFE SUPPORT
Edwin L. Force 415-694-3755
(506-41-61)

The primary goal of the Physical/Chemical Closed-Loop Life Support (P/C CLLS) Project is to provide the technology base required to sustain human life throughout long-duration space missions that will explore the solar system. The technical approach is based on a dual-path strategy which combines process, subsystem and system-level computer modeling and analysis with conventional laboratory research, development and testing activities. This approach will be applied to select and develop technology candidates for use in primary life support subsystems for air revitalization, water management, solid waste management and thermal control. Reliable, safe and efficient P/C CLLS systems for specific mission scenarios will be provided through integration of optimized subsystem designs. Supporting research and development efforts will be pursued in the area of systems control and automation. System-level analyses and assessments will be performed to assist in guiding and directing the overall research and development effort. Ames Research Center (ARC) is the designated Lead Center for the P/C CLLS Project. Other participating centers include Johnson Space Center (JSC), Marshall Space Flight Center (MSFC) and Jet Propulsion Laboratory (JPL). In contrast to FY-89, this RTOP covers only the FY-90 work to be performed at ARC. Separate RTOPs will be prepared by the other centers to cover their work in FY-90.

W90-70180 **(62) 591-34**
Marshall Space Flight Center, Huntsville, AL.
PHYSICAL/CHEMICAL LIFE SUPPORT TECHNOLOGY
J. L. Moses 205-544-1747
(506-41-00)

The primary goal of the Physical/Chemical Closed Loop Life Support (P/C CLLS) Project is to provide the technology base required to sustain human life throughout long duration space missions that will explore the solar system. Part of this overall project is development of the various types of monitoring and control instrumentation which will be needed for effective operation of the P/C CLLS. Another part of this project is development of trace organic removal processes to purify water. These tasks involve definition of requirements, technology assessment, hardware specification, prototype sensor and instrumentation development, and integration support. Specific objectives are to develop engineering specifications based on the requirements for each application; defining the optimum tradeoff considerations; coordinating instrumentation development; exploiting advanced technology from related activities by NASA, industry, and academia; and coordinating with the Systems Control Strategy element.

W90-70181 **(55) 591-34**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHYSICAL-CHEMICAL LIFE SUPPORT TECHNOLOGY
P. K. Seshan 818-354-7215

The objective of this RTOP is to continue the work described in former RTOP No. (55)506-41-61 and hence, provide systems analysis and assessment support to both the Closed Loop Life Support (CLLS) Project Office at Ames Research Center and to the CLLS Program Management at NASA Headquarters.

W90-70182 **591-36-32**
Ames Research Center, Moffett Field, CA.
HUMAN PERFORMANCE REQUIREMENTS
Bruce W. Webbon 415-694-6646
(199-06-12)

The overall research goals of this RTOP are to understand and minimize the effects of acute and chronic environmental stresses on human behavior, productivity, and well-being on long duration space missions. Research objectives are to: (1) define, structure and understand the behavioral impacts of isolation and confinement; (2) develop sound methodological procedures to study environmental influences on behavior; (3) conduct human-environment research in settings that approximate projected space mission conditions; (4) apply research results to identified problems in the design of space habitats, space transit vehicles, extravehicular activity (EVA) systems, and certain operational issues such as crew time scheduling and space food systems; (5) track and evaluate solutions in operational space and analog environments. The approach to the program of research covered by this RTOP is to produce operationally significant guidelines and recommendations based upon systematic scientific and experimental design practices. This program will integrate methodologies and findings of research conducted in multiple settings, including: laboratories, simulators, and a variety of field settings (polar and undersea habitats, surface ships, oil rigs, and confined institutional settings such as hospitals and prisons). First year efforts include: (1) develop three year program plan for conducting habitability research to define manned system requirements and design guidelines; (2) explore the behavioral effects of altered light-dark cycles; and (3) produce strategic plan for analog research.

Space Transfer

W90-70183 **(22) 591-41**
Lewis Research Center, Cleveland, OH.
CHEMICAL TRANSFER PROPULSION
L. A. Diehl 216-433-2438

The objective of this research 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 reusability.

W90-70184 **(23) 591-42**
Langley Research Center, Hampton, VA.
HIGH ENERGY AEROBRAKING
W. R. Hook 804-864-6055
(506-40-00)

This research is to develop the technology base required for the successful application of aerobraking to the high energy (hypervelocity) 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; Aerodynamics and Aerothermodynamics; and Guidance, Navigation, and Control. Studies to define overall missions, entry velocities, and candidate aerobraking vehicle concepts will be performed. Computational techniques will be developed, calibrated, and applied to predict the aerodynamic and aerothermodynamic characteristics for entry vehicles during aerobraking (or direct entry) maneuvers at Mars and during Earth return from Mars or lunar missions. Convective and radiative heating rates and flow field parameters will be predicted for real-gas flow conditions, including continuum and rarefied flow, at Mars and Earth for the complete forebody and afterbody configurations. Experimental investigations will be conducted to provide a timely, parametric aerodynamic/aerothermodynamic assessment of candidate configurations required for aerobraking performance optimization, and quantitative measurements will be used to calibrate CFD codes. Studies of onboard, autonomous, optimal guidance systems will be performed, and candidate aerobraking guidance laws will be developed and demonstrated.

W90-70185 (21) 591-42
Ames Research Center, Moffett Field, CA.
HIGH ENERGY AEROBRAKING
James 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 the Office of Aeronautics and Space Technology (OAST). Research areas include system analysis, aerothermodynamics and materials and structures. In systems analysis the major effort will be directed at the Piloted Mars Mission, but some studies of the Mars Sample Return Mission will also be considered. 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 candidate vehicles. This will be accomplished by improving or by developing new materials, heat shield concepts, and new structural/TPS systems.

W90-70186 (72) 591-42
Lyndon B. Johnson Space Center, Houston, TX.
HIGH ENERGY AEROBRAKING
Robert C. Ried 713-483-6608

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 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 technology as required for Mars missions.

W90-70187 (55) 591-42
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH ENERGY AEROBRAKING
Lincoln J. Wood 818-354-3137
(506-46-00)

The objectives and approaches of this RTOP are to perform mission and vehicle concept studies related to high-energy aerobraking. Techniques for designing nominal atmospheric aerobraking trajectories that satisfy specified end conditions, minimize propellant consumption, and meet heating rate and other constraints are developed. Atmospheric navigation approaches for aerobraking applications employing alternative estimation algorithms and measurement types are developed and compared along with the performance of various closed-loop, fault-tolerant, on-board atmospheric guidance schemes. Planetary approach guidance and navigation accuracies in aerobraking applications for various navigational data types, data processing scenarios, and maneuver strategies are assessed.

Aeroassist Flight Experiment

Lunar-to-Earth Aerobraking

W90-70188 (23) 592-01
Langley Research Center, Hampton, VA.
MODERATE ENERGY AEROBRAKING
W. R. Hook 804-864-6055

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 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 CFD 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.

W90-70189 (62) 592-01
Marshall Space Flight Center, Huntsville, AL.
MODERATE ENERGY AEROBRAKING
R. L. Morris 205-544-0804

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 space transfer vehicle (ASTV). Aeroassist technology significantly enhances the space transfer vehicle (STV) mission performance. Because the aerodynamic braking maneuver only allows penetrating 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 system designs for the ASTV. 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. Langley Research Center and Ames Research Center are responsible for development of other major experiments.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

Global Scale Atmospheric Processes

W90-70190 146-00-00
Langley Research Center, Hampton, VA.
GLOBAL ATMOSPHERIC PROCESSES
M. P. McCormick 804-864-2669

This RTOP covers several studies of atmospheric processes related to the improvement of 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. Studies of global atmospheric aerosols and the basic physics required to develop and utilize a Doppler laser wind sounder are also included.

W90-70191 **146-60-00**
Goddard Space Flight Center, Greenbelt, MD.
METEOROLOGICAL SATELLITE DATA APPLICATIONS
Robert Atlas 301-286-3604
(146-64-00; 146-65-00)

This RTOP utilizes 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 the understanding of atmospheric behavior. Advanced general circulation models and analysis methods are developed and satellite data is utilized in comprehensive 4-dimensional analysis for the atmosphere. The results are used to perform data impact studies, to diagnose and understand the dynamics of the atmosphere. The following results are expected: (1) utilization by the academic community of the new global fields developed in the 4-dimensional analysis; (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 the understanding of global scale atmospheric processes.

W90-70192 **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 physical processes and distribution characteristics associated with precipitation, including understanding associated cloud regimes will be investigated. Techniques will be developed for remote sensing of precipitation from aircraft and satellites (e.g., radar, microwave and visible/IR radiometers) also including related science for algorithm development. Statistical properties of rainfall to define sampling strategies in time and space and ways to improve and interpret in-situ rainfall measurement techniques for developing methods to validate (ground truth) space remote sensing measurements of precipitation will be investigated. Field experiments associated with physical processes studies will be conducted and algorithms, instrumentation, and ground truth schemes will be developed. Science investigations, including modeling and simulation studies, will be conducted, as well as planning studies for precipitation measurements from space.

W90-70193 **146-61-01**
Marshall Space Flight Center, Huntsville, AL.
SATELLITE DATA RESEARCH
F. W. Leslie 205-544-1633

This RTOP will contribute to the NASA Global Scale Processes Research Program objectives by performing diagnostic and theoretical studies of global-scale atmospheric systems to: (1) 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. Detailed analyses will be conducted 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.

W90-70194 **146-64-00**
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)

This RTOP investigates new methods for assimilating satellite data and conventional data into general circulation models to improve the 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.

W90-70195 **146-65-00**
Goddard Space Flight Center, Greenbelt, MD.
METEOROLOGICAL PARAMETER EXTRACTION
Robert Atlas 301-286-3604
(146-64-00; 146-60-00)

This RTOP will develop new and improved techniques for retrieving useful parameters from satellite-measured radiances and interpret these retrievals to provide information on the state of the atmosphere. Advanced methods for satellite temperature retrievals will be developed and methods to determine temperature, moisture, and precipitation from measurements of various portions of the electromagnetic spectrum will be researched. Expected results include techniques to determine atmospheric temperature and moisture profiles, cloud parameters, and surface parameters as well as validation of the retrieved products. Analyses of these data should improve our understanding and prediction of global scale atmospheric processes.

W90-70196 **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 continued improvement of numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the National Oceanic and Atmospheric Administration High Resolution Infrared Sounder/Microwave Sounding Unit (NOAA HIRS/MSU) sounders; (2) apply the retrieval methods to produce a ten-year data set (1979 to 1989) from the HIRS/MSU 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); and (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.

W90-70197 **146-66-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SEASAT WIND ANALYSIS AND STUDIES
P. M. Woiceshyn 818-354-5416

Research is directed towards: (1) the exploitation of

high-resolution scatterometer marine wind and wind stress measurements from Specialized Experimental Applications Satellite (SEASAT) and ESA Remote Sensing Satellite-1 (ERS-1) in global meteorological research, applications and prediction; (2) the exploitation of sophisticated techniques of visualization in order to gain the fullest information and insight from high-resolution, high-quality remotely sensed data; and (3) an enhanced understanding of scatterometer data meteorologically by collaboration with European Centre for Medium Weather Forecasts (ECMWF) and National Research Council-Venice (CNR) in the establishment of an ERS-1 database. Major objectives include: perform global and regional meteorological research using dealiased Seasat-A Satellite Scatterometer (SASS) and ERS-1 wind fields; continue to pursue methods for dealiasing and assimilating SASS data into numerical weather prediction models for application to short-range forecasts; and characterize the quality of the SASS and ERS-1 retrieval system utilizing the statistical packages developed by this project and ECMWF. SEASAT and ERS-1 data will be analyzed globally to perform the following tasks: perform case studies of special interest that are poorly analyzed and forecast by standard models; describe wind fields (SASS and ECMWF) in terms of principal components empirical orthogonal functions for potential application to statistical and/or dynamical forecasting; conduct application and impact studies of SASS marine wind data (in equatorial ocean-atmosphere interaction dynamics, frontal instability, diabatic marine boundary layer studies, and generation of synoptic pressure fields consistent with scatterometer wind data); produce color-animated time sequences of surface windflow patterns and pressure patterns in order to visualize the development of weather phenomena on both global- and meso-scales; and collaborate with ECMWF, Atmospheric Environment Service-Canada (AES), CNR-Venice, Naval Environmental Prediction Research Facility/Naval Ocean Research and Development Activity (NEPRF/NORDA), and Royal Netherlands Meteorological Institute (KNMI) in studies of the impact on numerical weather and wave forecasts of scatterometer wind data (SASS and ERS-1). Some of the research with ERS-1 data will be done at ECMWF.

W90-70198 **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 Rainfall Measuring Mission (TRMM). In FY-88, a breadboard for the 14 GHz channel of the dual frequency ARMAR system was completed. The system was used in FY-89 to test the level of pulse compression side-lobe suppression. The objective of FY-90 is to complete the development of the antenna subsystem, the 14 GHz channel fabrication, the procurement of long lead items for the 24 GHz channel, and the preparation for integration onto the DC-8. We will conduct a preliminary design review in early FY-90 to discuss the results of the 14 GHz breadboard tests. A critical issue is to determine whether to utilize a pulse compression scheme or to employ a traditional high peak power design. The antenna subsystem will be procured with its associated scanner mechanism. The 14 GHz high power transmitter will also be procured. The digital subsystem will be designed and fabricated and the interface with the RF subsystem will be tested. The mechanical design will be initiated for the radar so that it will be ready for aircraft integration in early FY-91. It has been requested by NASA Headquarters that a reduced scope plan be considered. In this plan, the detailed mechanical fabrication and DC-8 interface hardware development will be deferred until FY-91 and the system integration/test of the 14 GHz channel will also be deferred.

W90-70199 **146-70-00**

Goddard Space Flight Center, Greenbelt, MD.

METEOROLOGICAL OBSERVING SYSTEM DEVELOPMENT

S. H. Melfi 301-286-7024

This RTOP will develop new and improved spaceborne remote sensing systems in support of the NASA Global Weather Program and will 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, and atmospheric radiative properties, infrared, visible and microwave, and passive modes. Evaluation, in cooperation with other scientists, will be performed to assess improvement in weather forecasting. Improved techniques and instrumentation to observe profiles of atmospheric temperature, moisture and pressure, precipitation, surface properties, and atmospheric radiative properties leading to improved weather prediction are expected.

W90-70200 **146-71-00**

Wallops Flight Facility, Wallops Island, VA.

IN SITU/REMOTE INSTRUMENT ANALYSIS AND VERIFICATION

F. J. Schmidlin 804-824-1618

The upper-air instrument performance, behavior, and precision are examined using existing and new data sets in order to enhance knowledge of instrument precision and accuracy. Tried and proven methods will be used to continue development of temperature corrections for the U.S. standard radiosonde and other types of temperature sensors used in the U.S. Responses of satellite temperature retrievals (TOVS) to variations of atmospheric temperature including long- and short-wave, seasonal, and interannual oscillations will be investigated. Whether significant biases between satellite retrieved temperatures and radiosonde temperatures exist which results from calibration errors induced from radiosonde radiational errors will be determined. Various radiosonde systems and techniques will be tested and evaluated using the unique telemetry, radar, and computing capability located at Goddard Space Flight Center (GSFC)/Wallops Flight Facility. Daytime and nighttime observations will be studied in order to validate differences observed at these times. The newly developed temperature corrections for the rod thermistor of the U.S. standard radiosonde will be improved and up-to-date adjustments developed for those instruments compared in the World Meteorological Organization (WMO) International Radiosonde Intercomparison. There is evidence that temperature corrections at high latitudes will differ from lower latitudes. The long-wave error part of the temperature correction seems to be sensitive to clouds and emission from the atmosphere. New radiosonde types now available require special tests with these. One of the new radiosonde types permits eight separate sensors to be deployed simultaneously. This approach will permit the tests to be conducted much more efficiently than in the past. Both the European Centre for Medium Weather Forecasts (ECMWF) and National Meteorological Center (NMC) have expressed a desire to use the final temperature corrections when they become available. Radiosonde measurements are used to ground truth satellite retrieved temperatures. Methods to improve the applicability of these satellite measurements further will be designed and tested. Corrected and uncorrected radiosonde data will be compared with satellite retrieved temperatures. Thus, an estimate of satellite error resulting from the use of the current radiosonde and regression method can be quantified with greater precision.

W90-70201 **146-72-03**

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

IR REMOTE SENSING OF SST

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, with a high precision radiometer and atmospheric in situ sensing system, to test the transfer model of surface radiance to space. 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 make sensitivity studies of the effects of the present measurements in computations of heating for climate simulation.

W90-70202 **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 FY-90, the work will continue on an experimental study of vertical profiles of atmospheric backscatter at CO2 laser wavelengths in the 9 to 11 micron region. An emphasis will be placed on assessing the influence of visible and sub-visible cirrus on the backscatter to be expected, including seasonal dependence of probability of occurrence. This study is being conducted using an existing transversely excited atmospheric pressure laser (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 the University of California, Los Angeles (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.

W90-70203 **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 of this RTOP 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 National Oceanic and Atmospheric Administration High Resolution Infrared Sounder 2/Microwave Sounding Unit (NOAA HIRS2/MSU) satellite data. Other objectives include: (1) increasing the cost effectiveness of map/time-series production; (2) making the process of climatic map/time-series generation and data analysis more readily available to atmospheric scientists; and (3) providing 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 continue 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 Video Image Communication and Retrieval (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 computer controlled animation subsystem of differential-absorption lidar (DIAL). The integration of computer graphics and image processing techniques will be added as a means of 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.

W90-70204 **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 Jet Propulsion Laboratory (JPL) Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO2 lidar targets. Customers in the lidar community 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 are specified by the customer. The measurement result provided to the customer for each set of specified parameters is 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 is used with the objective of maintaining 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 is achieved through careful experimental techniques such as incorporating spinning targets to reduce speckle effects. Continuity between the three measurements 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).

W90-70205 **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 micron 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 range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation will initially consist primarily of the design and fabrication 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 would be flown on the NASA DC-8 on at least two latitude survey missions over the Pacific Ocean and possibly will be analyzed and considered in the context of related instrument measurements of atmospheric aerosols and other atmospheric parameters.

W90-70206 **146-73-00**
Marshall Space Flight Center, Huntsville, AL.
OBSERVING SYSTEMS DEVELOPMENT
J. E. Arnold 205-544-1646

The objective of this RTOP is 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. This will be accomplished by utilizing the talents of university, nonprofit and industrial contractor groups plus the MSFC in-house talents and laboratory capabilities.

W90-70207 **146-73-10**
Ames Research Center, Moffett Field, CA.
CO2 LIDAR BACKSCATTER EXPERIMENT
R. F. Pueschel 415-694-5254

The objective is to measure aerosol size distributions and particle shapes simultaneously 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 (Laser Atmospheric Wind Sounder). The approach is to fly impactors and laser spectrometers on the Ames DC-8 aircraft to measure the global variability 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.

W90-70208 **146-76-02**
Marshall Space Flight Center, Huntsville, AL.
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 the 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 provided for the scientific data analyses of the geophysical fluid flow experiment flown on Spacelab 3 and detailed experiments for flight of the Geophysical Fluid Flow Cell (GFFC) on the International Microgravity Laboratory.

Upper Atmospheric Research Program

W90-70209 **147-00-00**
Langley Research Center, Hampton, VA.
UPPER ATMOSPHERIC RESEARCH
W. Ray Hook 804-864-5380

The objective of this RTOP is to support specific field measurements, theoretical and analytical studies, and laboratory investigations aimed at improving the knowledge of the Earth's upper atmosphere and its potential for change. Field measurement work will be focused on development of a far IR balloon experiment for HO(x) gases, on validation of stratospheric ozone measurements with a ground-based microwave instrument, and on analysis of lidar ozone and aerosol data and in situ ozone data obtained during the 1989 Airborne Arctic Stratospheric Experiment. In collaboration with other atmospheric spectroscopy groups, high resolution IR balloon and ground-based spectra will be analyzed for quantification of trace gas concentrations, trends, and variabilities. Theoretical and analytical research will emphasize computational chemistry studies of stratospheric molecules and development of retrieval methods for ground-based, mm-wave measurements of stratospheric gases. High resolution laboratory spectroscopy work will be focused on Fourier transform spectrometer and tunable diode laser studies of ozone intensities and ozone and methane linewidths. Specific atmospheric measurement and laboratory tasks will be supported upon recommendation of the NASA Upper Atmospheric Research Program.

W90-70210 **147-11-00**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERIC RESEARCH - FIELD MEASUREMENTS
William S. Heaps 301-286-5106

The objective of this RTOP is 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 balloon borne laser radar. The anticipated outcome of these efforts include absolute concentration measurements of a variety of trace atmospheric constituents.

W90-70211 **147-11-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IN SITU MEASUREMENTS OF STRATOSPHERIC OZONE
J. J. Margitan 818-354-2170

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 resolution (better than 100 meters). These data will serve as a comparison to other in situ and remote sensing techniques. This research effort is a collaborative project with the National Oceanic and Atmospheric Administration (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.

W90-70212 **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, with the additional possibility of altitude profiling. The current measurement capability includes NO, NO2, O3, j(NO2), HNO3, HCl, H2O, CH4, N2O, CO2, and minor gas isotopes. A compact version of this instrument is currently being designed and built for operation on the ER-2 aircraft to participate in polar campaigns. This Aircraft Laser Infrared Absorption Spectrometer (ALIAS) instrument will employ a multipass gas cell with measurement capability for NO2, O3, HCl, CH4, H2O, and HNO3.

W90-70213 **147-12-00**
Ames Research Center, Moffett Field, CA.
AIRBORNE IR (INFRARED) SPECTROMETRY
S. Wegener 415-694-6278

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 (IR) absorption and emission spectrometers on balloons and aircraft in coordination with other experimenters in order to identify constituents and infer concentrations from spectra obtained.

W90-70214 **147-12-00**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - FIELD MEASUREMENTS
J. E. Mentall 301-286-8959

This RTOP has the following objectives: (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 approach is to: develop a balloon-borne Michelson interferometer and measure the concentrations and diurnal variations of trace stratospheric species; develop a pointed spectrometer system and measure the solar photon flux within the stratosphere; and perform multi-instrument, coordinated measurements on minor species in the stratosphere and develop photochemical models to compare experimental results with theoretical predictions. The following results are expected: improvement and validation of photochemical models; improvement of understanding of upper atmosphere composition, chemistry, dynamics, and transport; determination of in-situ solar flux and the accuracy of radiative transfer calculations; and obtain effective absorption cross sections for O2 and O3.

W90-70215 **147-12-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRATOSPHERIC FOURIER SPECTROSCOPY
G. C. Toon 818-354-8259

The task has two distinct science objectives. The first is to acquire high quality infrared stratospheric survey spectra, recorded at different latitudes and seasons. 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 of interest, or molecules whose spectroscopic parameters are currently insufficiently well known to permit a critical test of theory. The second objective is to analyze these spectra to determine the atmospheric composition with suffucient 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 4 Balloon Interferometer. Measurements have been and will be 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., the north and south polar regions.

W90-70216 **147-12-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MM AND SUB-MM RADIOMETRY: BALLOON MICROWAVE LIMB SOUNDER (BMLS)
R. A. Stachnik 818-354-1921

The objective of this program is to improve understanding of Earth's upper atmosphere by balloon-based microwave measurements at millimeter and submillimeter wavelengths. 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 may involve instrument development or improvement. One important goal of this 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.

W90-70217 **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 will 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 mixing ratio profiles between 25 km and 46 km with 3 km vertical resolution. Column density of OH above 46 km will also be retrieved. The instrument is compact (9.36 cu m), light-weight (68 kg), requires low power (30 W), and thus is well suited to balloon observations.

W90-70218 **147-13-00**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - OZONE GROUND STATION
T. J. McGee 301-286-5645

The objective of this RTOP is to measure stratospheric ozone from the ground with a sensitivity sufficient to detect predicted long-term trends. The approach is 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, in accordance with sharing the trailer with water vapor lidar. A major intercomparison will take place at Table Mountain Observatory in July 1989. Other intercomparisons will be planned for 1990.

W90-70219 **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 (TMO) at Wrightwood, California, from which to make atmospheric measurements. The 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 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. Participation in ground-truth and correlative measurements for space-borne instruments, such as Upper Atmosphere Research Satellite (UARS) and Earth Observing System (EOS) is also an important capability of the JPL-TMO facility.

W90-70220 **147-13-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NETWORK FOR DETECTION OF STRATOSPHERIC CHANGE
W. J. Wilson 818-354-5699

The objective of this task is to continue to support the development and operation of the Network for the Detection of Stratospheric Change (NDOSC) station at Table Mountain Observatory (TMO). The TMO station will monitor the amount of

ozone and water vapor at different altitudes in the middle atmosphere through the use of ground based, upward looking radiometers operating near 22 and 110 GHz. The 22 GHz water vapor radiometer is being developed and constructed by Dr. P. R. Schwartz at the Naval Research Laboratory, the 110 GHz ozone radiometer by Dr. A. Parrish at the Millitech Corporation. These are prototype instruments which are based on proven designs but are individually made for this installation. The TMO will provide an all-weather, year round, 24-hour-per-day operating site with provisions for uninterrupted electrical power, on-site surface weather monitoring and archiving, and direct, on-line access to the radiometer data and station ephemeris from off-site locations through a MODEM accessible local area network. The present schedule calls for completion of the TMO container by June 1989, followed by installation of the ozone instrument in June. Following this will be a series of measurements in July together with the TMO lidar ozone profiler, operated by Dr. S. McDermid of JPL. These measurements will coincide with an overpass by the Stratospheric Aerosol Gases Experiment (SAGE) satellite. The water vapor instrument is scheduled for installation in September 1989. JPL will provide support for the installation, operation and maintenance of these radiometers, and personnel at JPL will also be involved in the analysis of their data. In addition, the station design will evolve, as the instruments become operational, with the intent of providing a reliable, long-term, semi-autonomous remote facility for the NDOSC.

W90-70221 **147-14-00**
Goddard Space Flight Center, Greenbelt, MD.
ANTARCTIC OZONE PROJECT
Arlin J. Krueger 301-286-6358

The objective of this RTOP is to analyze the formation of polar ozone minima and to provide Total Ozone Mapping Spectrometer (TOMS) data products in a timely manner to scientific users and agencies, especially while research on Antarctic and Arctic ozone changes is being conducted. The approach is to produce ozone data files and transmittable data sets or graphical products on a next-day basis and to analyze the development of ozone minima in relation to meteorological and chemical causes.

W90-70222 **147-14-00**
Ames Research Center, Moffett Field, CA.
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, 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 three existing projects and possible future projects. The first is the Stratosphere-Troposphere Exchange Project (STEP), with the following goals: (1) improve understanding of processes that move chemicals into the stratosphere and toward the ozone layer; and (2) explain the extreme dryness of the stratosphere. Its platform is the ER-2. Its missions are in 1984 to 1987, including 12 ER-2 flights in January and February 1987 from Darwin, Australia to study exchange processes in the tropics. The second project is the Airborne Antarctic Ozone Experiment (AAOE). Its goal is to explain the cause of the large ozone depletion that has developed during Antarctic springtimes over the past decade. Its platforms are the ER-2 and DC-8. Its missions are multiple ER-2 and DC-8 flights over Antarctic, based in Punta Arenas, Chile, August and September 1987. The third project is the Airborne Arctic Stratospheric Expedition (AASE), an ER-2/DC-8 mission based in Norway, January and February 1989, to study ozone depletions and polar stratospheric clouds in northern high latitudes. Possible future projects include a return to the Antarctic Current activities center on data analysis.

W90-70223 **147-14-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE MICROWAVE TEMPERATURE PROFILER INVESTIGATIONS OF ATMOSPHERIC DYNAMICS RELATED TO OZONE DEPLETION
B. L. Gary 818-354-3198

The proposed work consists of two parts: analysis of existing data taken with UJPL's ER-2 Microwave Temperature Profiler (MTP) during the Airborne Antarctic Ozone Experiment (AAOE) and the Airborne Arctic Stratospheric Expedition (AASE); and construction of an MTP type instrument for NASA's DC-8 aircraft for use in a future Antarctic flight mission. This second item is a new task. Both tasks are designed to study atmospheric dynamic phenomena related to polar ozone depletion. The ER-2 data analysis task will be conducted using standard computer and programming capabilities. The second task will be accomplished by constructing a passive microwave radiometer similar in design to the ER-2 MTP instrument. The DC-8 MTP will be constructed and environmentally tested during the first year. During the second year it will be installed in the DC-8, and test flights will be used to calibrate and characterize the instrument's performance, so that it will be ready for the next ozone hole deployment.

W90-70224 **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 the 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 borne instruments are used to measure the properties of the upper atmosphere and the 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 include: (1) measurement of trace constituents, temperature and density of the upper atmosphere; and (2) determination of 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.

W90-70225 **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)

Continuing technical, logistical, and operational support of stratospheric balloon flights is provided to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Two modular gondola systems can 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 in the same air mass is used for instrument intercomparison purposes and for the validation of atmospheric chemical models.

W90-70226 **147-18-00**
Wallops Flight Facility, Wallops Island, VA.
ECC (ELECTROCHEMICAL CONCENTRATION CELL) OZONESONDE TESTS AND DEVELOPMENT
A. L. Torres 804-824-1553

The objectives of this RTOP are to: (1) continue a study of electrochemical concentration cell (ECC) ozonesonde performance under simulated high-altitude conditions; and (2) conduct the fourth in a series of annual studies of stratospheric ozone over Antarctica aimed at evaluating long-term trends in depth and vertical extent

of the ozone hole. A study of the performance of ECC ozonesondes under simulated stratospheric conditions in a laboratory-based flight simulator will be continued. A series of ozonesonde soundings will be conducted from Palmer Station, Antarctica, during the austral spring of 1990. This latter effort will further characterize trends in polar ozone losses that occur during this season.

W90-70227 **147-21-02**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE - REACTION RATE AND OPTICAL MEASUREMENTS
Louis J. Stief 301-286-7529

The objective of this program 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 the capability. This allows the determination of reaction channels and provides 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., 8(1D) and ClO.

W90-70228 **147-21-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHEMICAL KINETICS OF THE UPPER ATMOSPHERE
M. T. Leu 818-354-2432

The objectives of this RTOP are to obtain direct measurements of kinetic rate parameters for homogeneous and heterogeneous reactions important in stratospheric chemistry and to develop new experimental techniques for laboratory study of polar ozone chemistry.

W90-70229 **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.

W90-70230 **147-22-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The objective of this RTOP is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

W90-70231 **147-22-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC PHOTOCHEMISTRY
M. J. Molina 818-354-5752

Laboratory studies will be conducted to elucidate the photochemistry of atmospheric species, with particular emphasis on the polar stratosphere. The experiments will include chemical reactions involving: (1) ice particles, and (2) sulfuric acid, nitric acid and hydrochloric acid-ice solutions and hydrates. Measurements of reaction rate constants will be carried out involving: radicals and various polar molecules over an extended pressure and temperature range; absorption cross sections as a function of wavelength and temperature; and Fourier Transform Infrared (FTIR) spectra of reaction intermediates.

W90-70232 **147-23-00**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - LABORATORY MEASUREMENTS
T. J. McGee 301-286-5645

The objectives of this program are the following: (1) to support ongoing lidar experiments; (2) to perform laboratory studies to test the feasibility of measurements of additional species; (3) to test and calibrate new instruments; and (4) measurement of UV absorption cross-sections of importance in atmospheric photochemistry. The approach is to measure spectroscopic parameters of important atmospheric constituents in all regions of the spectrum from the VUV to submillimeter waves. Studies will be performed in both absorption and emission. Quantitative spectroscopic data will be measured for a more accurate interpretation of current field experiments and to demonstrate the feasibility of new field measurements.

W90-70233 **147-23-00**
Ames Research Center, Moffett Field, CA.
QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE
C. Chackerian, Jr. 415-694-6300

Remote and in-situ detection and measurement of stratospheric minor constituent species via spectroscopic techniques are being routinely employed to develop a better understanding of this portion of our atmosphere and man's affect 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, as well as to develop new spectroscopic techniques to detect species in question. 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.

W90-70234 **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 micrometer) coincide with those used by NASA field experiments that do remote sensing by high resolution spectroscopy. These are Atmospheric Trace Molecule Spectroscopy (ATMOS), Balloon Borne Laser In Situ Sensor

(BLISS), Mark 4, Upper Atmosphere Research Satellite (UARS), and Earth Observing System (EOS). The laboratory spectra will be recorded at spectral resolutions of 0.00289/cm, 0.0056/cm, and 0.011/cm 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.

W90-70235 **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 stratospheric measurements made using infrared spectroscopy, specifically by the Balloonborne Laser In Situ Sensor (BLISS) infrared laser instrument and also the Mark 4 and Atmospheric Trace Molecule Spectroscopy Fourier Transform Infrared (Spectroscopy) (ATMOS FTIR) spectrometers. Line positions, absorption strengths, and air broadening coefficients are the spectral parameters measured, including their dependence on temperature. New spectroscopic techniques for sensitivity enhancement and spectral line-shape analysis are also investigated.

W90-70236 **147-23-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MILLIMETER AND SUBMILLIMETER SPECTROSCOPY IN SUPPORT OF UPPER ATMOSPHERIC RESEARCH
E. 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 and generation of spectral line lists. These will be made available for distribution to the field measurement community via the separately funded JPL Microwave Millimeter and Submillimeter Spectral Line Catalogue. 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 data base and made available to interested users. Recently this program has provided valuable molecular structural information which has direct bearing on proposed mechanisms for polar ozone destruction. Work in this area will continue.

W90-70237 **147-51-00**
Goddard Space Flight Center, Greenbelt, MD.
ASSESSMENT AND COORDINATION
Richard S. Stolarski 301-286-9111

The objectives of this RTOP are to form committees of leading scientists to evaluate the state of knowledge concerning ozone trends and to prepare reports summarizing the present knowledge. The Ozone Trends Panel Chapter summaries have been published in a NASA Reference Publication. The main report is in process of final pasting of the text and figures. A new set of committees has been formed to provide an updated assessment for the United Nations Environmental Program review of the Montreal Protocol on chlorofluorocarbons. The final full Ozone Trends Panel Report will be published. Preparations will continue for the next evaluation which will emphasize intercomparison of model predictions.

W90-70238 **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.

W90-70239 **147-51-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH SCIENCE PROGRAM SUPPORT
D. L. Evans 818-354-2418

The objective of this RTOP is to support the NASA Earth Sciences and Applications Division in: (1) interdisciplinary studies of earth science including mechanisms of climate change, land-air and ocean-atmosphere interactions, and impact of land processes on other earth systems; (2) studying techniques for earth observations; and (3) explore new concepts for earth probe class instrument/missions. Distinguished visiting scientists, including Dr. Robert Dickinson, Professor David Gates, M. Skolnick and Professor Richard Lindzen, will be invited to JPL for periods of a few weeks to a few months to consult and collaborate with JPL scientists in these studies. Several graduate students will be supported while doing their thesis research at JPL in these interdisciplinary areas. Their research will be directed by the distinguished visiting scientists and by JPL science staff members.

W90-70240 **147-90-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ESSC/DISTINGUISHED VISITING SCIENTISTS
M. T. Chahine 818-354-6057

The objective of this RTOP is to provide support to the NASA Earth System Sciences Program. Remote sensing techniques will be developed and applied to study surface processes and their interaction with the atmosphere. Science support in this area will be provided with the assistance of Professor R. Goody. In addition, support from P. Niiler, M. McElroy, J. Baker and P. Blanchard will be provided as needed. The level of support could be modified, subject to Code EE and JPL agreement. The development of the Global Energy and Water Cycle Experiment (GEWEX) for World Meteorological Organization (WMO) and NASA will be supported. Standards for global geophysical data sets will be developed. The specific objective is to establish practical criteria for validation, calibration and long-term stability which can be implemented not only by NASA, but also by international programs such as International Space Year (ISY). Support in this area will be provided by M. T. Chahine in collaboration with specialists at JPL. Recommendation to Code EE will be made in a timely manner to impact NASA activities including Earth Observing System (EOS), GEWEX, and the detection of increased greenhouse effects.

Planetary Geology R&A

W90-70241 **151-01-20**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY GEOLOGY
D. 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 characterize the gases released by thermal decomposition of Martian surface analog materials and evaluate the feasibility of accomplishing such analyses in situ; and (2) to determine the thermochemical properties and kinetics of potential regolith material on Mars and Venus.

W90-70242 **151-01-60**
Ames Research Center, Moffett Field, CA.
SOLAR SYSTEM STUDIES
P. Cassen 415-694-5597

The objective of this RTOP is to contribute to the understanding of the origin and evolution of the Solar System, one of NASA's most basic goals. Research is focused on modeling the processes that led to the formation of the planets. The results obtained are of both immediate and long-term value to NASA in guiding the planning of future missions to primitive bodies, outer planets, and Mars. The approach of the RTOP is to use theoretical concepts, physical insight, and mathematical modeling 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: (1) the dynamics and evolution of the solar nebula and protostellar disks in general; (2) the nature of primitive bodies such as comet nuclei; (3) the formation of planets and satellites; (4) the structure and origin of planetary rings; and (5) the interaction of planetary atmospheres with surfaces.

W90-70243 **151-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETOLOGY
S. M. Baloga 818-354-2219

This RTOP is a collection of individual Planetary Geology and Geophysics tasks with the objective of improving the understanding of: (1) physical processes and compositions on planetary surfaces; (2) solar system formation and dynamics; and (3) the interaction between solid body dynamics and planetary surface features. The scope of studies under this RTOP addresses planets, satellites, the moon, asteroids, comets and the solar system itself. A variety of disciplines are included in this collection of tasks, ranging from theoretical studies to photogeology, comparative planetology and data analysis. Many of the geologically-oriented tasks feature supplementary studies of analog geologic processes that occur on the earth. Other observationally-oriented tasks include laboratory studies of materials believed to occur on planetary surfaces. The primary objective of this research is an increased understanding of geologic and geophysical processes in the solar system, with emphasis on both the present characteristics of planetary bodies and their origin and geologic history. These studies include the scientific interpretation of data from past missions and provide support for the planning and instrumentation of future missions. This RTOP supports various computational, experimental, and image processing facilities and capabilities at JPL, including the NASA Regional Planetary Image Facility.

W90-70244 **151-02-50**
Goddard Space Flight Center, Greenbelt, MD.
MARS GEOLOGY: MAJOR RESURFACING EVENTS IN MARTIAN HISTORY
Herbert Frey 301-286-5450

The objectives of this program are to: (1) determine the number and crater retention ages of major resurfacing events in Martian history and their relation to the overall geologic evolution of the planet, using the Neukum and Hiller approach and techniques we have derived from it; (2) determine the thickness of materials associated with different resurfacing events and develop a stratigraphy based on resurfacing events that can be applied at many locations around Mars; and (3) provide support to National Space Science Data Center (NSSDC) for supplying planetary data. The approach is as follows: (1) for a given region of study, determine boundaries of major terrain units within which crater counts can be done for craters larger than 3 km diameter, using the 1:2 M controlled photomosaics; (2) produce cumulative frequency curves for each unit, and use the Neukum and Hiller approach to break these curves where they depart from standard production curves; (3) determine the effect of using different production curves in terms of the number and resulting crater retention ages of major resurfacing events; (4) for well determined events, use the smallest surviving crater from each branch that defines the resurfacing to determine the maximum thickness of overlying materials; (5) iteratively determine the thickness of materials associated with each event; (6) correlate major resurfacing events, ages and thicknesses between different regions to build up a picture of the global resurfacing history and a stratigraphy based on this which locates surfaces of different ages at depth; and (7) respond to requests for planetary data. A global picture of the major resurfacing events in Martian history, together with the depth to buried surfaces of common crater retention age is expected as a result of this program.

W90-70245 **151-02-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY GEOPHYSICS AND TECTONICS
Maria T. Zuber 301-286-2129

The broad objective of the proposed work is to gain insight into the mechanical structures and stress histories of the lithospheres of the terrestrial planets, with emphasis on Mars and Venus. In particular, several general studies in planetary geophysics and tectonics are proposed: (1) an analysis of deformational instabilities in a horizontally stressed, strength-stratified lithosphere that contains a detachment surface, with the goal of better understanding the mechanics and style of tectonics on Venus; (2) the examination of faulting models for the tectonic development of Martian plains ridges, in order to explore the state of stress of the Martian lithosphere; (3) an assessment of the extent to which regional variations in deformational wavelengths on Venus can be interpreted as due to variations in lithosphere structure or deformational history, in order to better understand Venus' lithosphere structure; and (4) the development of models to explain stresses associated with the formation of tectonic features in the calderas of the Tharsis shields, with the goal of understanding the mechanics of these volcanic constructs.

Planetary Materials

W90-70246 **152-11-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: MINERALOGY AND PETROLOGY
D. 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.

W90-70247 152-12-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY
D. 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.

W90-70248 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
(188-44-57)

The objectives of this program are: (1) to 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 system designed to produce grains rather than clusters and able to produce large amounts of 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 Scanning Electron Microscope (SEM) and Scanning Transmission Electron Microscope (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.

W90-70249 152-13-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: CHEMISTRY
D. 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.

W90-70250 152-13-60
Ames Research Center, Moffett Field, CA.
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.

W90-70251 152-14-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: GEOCHRONOLOGY
D. 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.

W90-70252 152-15-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: ISOTOPE STUDIES
D. 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.

W90-70253 152-17-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES
D. 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.

W90-70254 **152-17-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY MATERIALS AND GEOCHEMISTRY
S. M. Baloga 818-354-2219

The objective of this RTOP is to further the understanding of the solar system by using meteoric materials and features to develop constraints on physical processes in ancient asteroidal regoliths. The approach is an experimental study of the characteristics of gas-rich meteorites, followed by the development of inferences and constraints on the possible role of a T-Tauri sun. The investigation of planetary materials is an important part of the NASA mission to explore the solar system and further the understanding of its characteristics. Results from these studies provide insight and support for the planning and instrumentation of future missions.

W90-70255 **152-20-01**
Goddard Space Flight Center, Greenbelt, MD.
MICROGRAVITY NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS
J. Nuth 301-286-9467
(152-12-40; 188-44-57)

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 O gravity (t 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.

W90-70256 **152-20-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: COLLECTION, PRESERVATION AND DISTRIBUTION
D. 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 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. It 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; staff members participate in field collection. It also 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; as well as 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.

W90-70257 **152-30-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES
D. P. Blanchard 713-483-5151

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 costs 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 programs and other agency programs. The PMGP is asked to support about 20 percent of the modernization.

Planetary Atmospheres R&A

W90-70258 **154-10-80**
Ames Research Center, Moffett Field, CA.
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-694-5530

The objectives of this RTOP is to determine the properties and physical processes characteristic of planetary atmospheres by means of theoretical modeling and spacecraft data interpretation. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. The approach of this RTOP is to reduce and analyze data returned from spacecraft missions, such as Pioneer Venus and Voyager or to prepare 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.

W90-70259 **154-20-80**
Ames Research Center, Moffett Field, CA.
DYNAMICS OF PLANETARY ATMOSPHERES
R. E. Young 415-694-5521

The objectives of this RTOP are to model the atmospheres of Venus and Mars and 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. The approach of this RTOP is to study the dynamics of the atmospheres of Venus and Mars using multi-dimensional circulation models. The coupled momentum

and energy equations are solved numerically using combinations of finite difference and spectral methods.

W90-70260 154-20-80
Goddard Space Flight Center, Greenbelt, MD.
AEROSOLS CONDENSATE AND DYNAMICAL PROPERTIES OF PLANETARY ATMOSPHERES
V. G. Kunde 301-286-5693

This RTOP supports advanced data analysis for aerosol and dynamical properties of planetary atmospheres. One task addresses derivation of optical and dynamical properties of the Martian atmosphere from Mariner 9 infrared spectra and Mariner 9 and Viking orbiter images. Another addresses the determination of the haze production and investigation of dynamics in Saturn's and Titan's stratosphere from photochemical models.

W90-70261 154-20-80
Goddard Inst. for Space Studies, New York, NY.
INVESTIGATION OF COMPARATIVE PLANETARY DYNAMICS
Michael Allison 212-678-5554

The general objective of this work is to explore the role of stratification, eddy mixing, and diabatic processes in controlling the structure and circulation of planetary atmospheres under a range of dynamic, thermodynamic and radiative conditions. Numerical studies of Venus and Titan are expected to help assess the importance of both barotropic eddy and thermal tide interactions with the Hadley circulation in producing equatorial superrotation. Analytic and numerical studies of the Jovian planets will be designed to explore the effects of convective stratification and diabatic forcing in the context of shallow flow geometry. A new effort will be devoted to the study of the general circulation of Mars, with attention to the atmospheric transport and radiative-dynamical feedback of dust. The approach is as follows: (1) analytic diagnostic studies of the equations of atmospheric motion simplified by scalings appropriate for fast rotation, variable stratification, and dissipation, including the associated potential vorticity balance; (2) experiments 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 relevant to Venus and Titan; and (3) development of a Mars general circulation model (GCM) with an interactive boundary layer parameterization for the lifting of dust from the surface.

W90-70262 154-20-80
Goddard Inst. for Space Studies, New York, NY.
INVESTIGATION OF THE TEMPORAL AND SPATIAL VARIABILITY OBSERVED IN THE JOVIAN ATMOSPHERE
Barbara E. Carlson 212-678-5572

The general objectives are to: (1) develop a cloud retrieval algorithm with which to characterize the observed 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 charge coupled device (CCD) images. Principal elements in the approach are: (1) analysis of the spectro-photometric Jovian data obtained from 1980 to present to obtain information on temporal variation in the Jovian cloud cover with an emphasis on the North Equatorial Belt (NEB), Equatorial (EqZ) and South Equatorial Belt (SEB); (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 refine the radiative transfer techniques used to analyze the polarimetric images.

W90-70263 154-30-80
Ames Research Center, Moffett Field, CA.
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 is being used to simulate the haze on Titan, dust storms and water ice fogs on Mars and is being readied to investigate the methane clouds on Uranus.

W90-70264 154-40-80
Goddard Inst. for Space Studies, New York, NY.
RADIATIVE TRANSFER IN PLANETARY ATMOSPHERES
Barbara E. 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 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 refinement of radiative transfer algorithms which use a modification of direct spectral integration techniques to model molecular absorption and the single Gaussian-quadrature point and standard versions of the doubling and adding techniques to model multiple scattering; (2) continued analysis of thermal infrared data for Jupiter 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.

W90-70265 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; 188-44-57)

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), 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 (FTS) spectra are composed of more than one molecular transition, and the parameters: (1) frequency, (2) strength, (3) lower state energy, and (4) 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 revolved 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.

W90-70266 154-60-80
Ames Research Center, Moffett Field, CA.
THEORETICAL MODELING STUDIES OF MOIST CONVECTION ON THE OUTER PLANETS
C. R. Stoker 415-694-6490

The objective of this RTOP is to understand the physical

processes associated with moist convection on the outer planets. The following will be investigated: (1) effect of cloud microphysical processes on bulk cloud structure in the atmospheres of the outer planets Jupiter, Saturn, Uranus and Neptune; (2) the manner in which cloud precipitation formation and mass loading of updrafts by condensates affects the dynamics of convective clouds; and (3) the conditions required to initiate moist convection on the outer planets. The approach of this RTOP is to use an existing computer program which simulates formation and growth of condensates in a cloud. The program is being modified to include physical processes and condensable constituents that occur on the outer planets. Numerical experiments will be performed with the program to study how cloud microphysical processes affect bulk cloud structure on the outer planets. A one-dimensional numerical model of a moist convective cloud has been developed and will be interfaced with the cloud microphysical model to determine the effect of mass loading and cloud microphysical processes on cloud dynamics. Numerical experiments will be performed to determine what conditions are required to initiate moist convection. Case studies for Jupiter, Uranus, and Neptune will be run to help understand the cloud structure on each of these planets.

W90-70267 **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.

W90-70268 **154-75-80**
Goddard Space Flight Center, Greenbelt, MD.
COSMIC CHEMISTRY: AERONOMY, COMETS, GRAINS
J. E. Allen, Jr. 301-286-5896
(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; the spectra and vaporization of initially deposited and irradiated films are measured with a Fourier Transform Infrared (Spectroscopy) (FTIR) and a mass spectrometer. Formation and properties of porous, low density ice/dust aggregates are measured representing components for the cometary nucleus. Theoretical models of the nucleus are developed.

W90-70269 **154-90-80**
Ames Research Center, Moffett Field, CA.
PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS
W. J. Borucki 415-694-6492

The objectives of this RTOP 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 approach of this RTOP 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 association of the lightning activity on Jupiter with cloud features. A theoretical model of the lightning discharge column is being constructed to identify the physical processes that produce specific molecular products. Laboratory work is being conducted to determine the yield of various molecules produced by lightning discharges.

W90-70270 **154-95-80**
Ames Research Center, Moffett Field, CA.
MARS 3-D GLOBAL CIRCULATION MODEL
R. Haberle 415-694-5491

The objective of this RTOP is to further the understanding of the processes controlling seasonal cycles of dust, water, and carbon dioxide that characterize the climate of Mars. 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 approach of this RTOP 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

W90-70271 **155-05-80**
Goddard Space Flight Center, Greenbelt, MD.
MEVTV: EARLY MARTIAN TECTONICS
Herbert Frey 301-286-5450

The objectives of this RTOP are as follows: (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 (VM) and related older canyons to constrain the pre-Tharsis lithospheric stress on Mars; and (4) develop a classification of likely volcanic landforms on Mars. The approach is to: (1) search for evidence of a Borealis Basin in terms of radial or concentric structures through scaling comparisons with the Hellas impact basin; (2) search for evidence of a missing rim in western Mars; (3) define morphological terrain units, produce cumulative frequency curves and analyze these in terms of Neukum-Hiller resurfacing events; (4) correlate the age of these events with other major geological events on Mars; (5) prepare a structural map of the Valles Marineris and related canyons (Echus, Juventae) and associated graben; (6) determine the fault distribution, regions of likely fault interaction and fault propagation; (7) use linear elastic fracture mechanics to determine the stress orientation and magnitude, fault propagation forces and contributions to lateral growth of the VM from Tharsis tectonism; and (8) compare classification of likely Martian volcanic landforms with similar schemes for terrestrial volcanic features. An improved model for the origin of the Martian crustal dichotomy and better constraints on the origin and evolution of the Valles Marineris are expected. Distribution maps of each type of probable landform will be provided.

W90-70272 **155-20-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM - DEVELOPMENT, OPERATIONS AND COORDINATION
J. T. Renfrow 818-354-6347
(656-61-06)

The objectives are to develop and implement an operational Planetary Data System (PDS), to develop operational discipline nodes, to develop detailed mission interfaces with the active flight missions, and to deliver the completed PDS including the central node, the observation geometry node (Navigation Ancillary Information Facility), and the operating discipline nodes. JPL will transition from a testbed phase into an operational phase and therefore there will be a transfer from experimental testbed nodes to more formalized discipline nodes selected through a NASA research announcement process. 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, new discipline nodes, and the operational PDS will be conducted under this RTOP in order to have effectively coordinated development. The process of selecting discipline 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 nodes. Detailed mission engineering activities will be initiated.

W90-70273 **155-20-80**
Langley Research Center, Hampton, VA.
DATA ANALYSIS FOR LDEF (LONG DURATION EXPOSURE FACILITY) EXPERIMENTS
William H. Kinard 804-864-3796

The objective of this RTOP is to perform post Long Duration Exposure Facility (LDEF) retrieval processing, data analysis and reporting for the following three science experiments which are currently flying on the LDEF: (1) chemistry of meteoroids (A0187-1); (2) chemical and isotopic measurements of meteoroids (A0187-2); and (3) interplanetary dust (A0201). The principal investigators for the respective experiments will perform the post retrieval processing, data analysis and reporting for these experiments.

Halleys Comet Watch/Experiments

W90-70274 **156-02-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERNATIONAL HALLEY WATCH
R. L. Newburn, Jr. 818-354-2319

The International Halley Watch (IHW) was designed to maximize the scientific value of ground-based observations of Halley's Comet. Important in their own right, such observations have also enhanced the value of space observations, setting the brief duration flyby data in the context of the overall apparition, placing the extremely high resolution encounter data into the normal scale of observations, and filling in missing data. The IHW standardized observing techniques wherever useful and possible, coordinated the observing, and has now collected 20 Gbytes of data for publication in a comprehensive Halley archive. The IHW was designed to avoid the problems of 1910 where the two major monographs on Halley were not published until 21 and 24 years later and where much data remains unpublished to this day. The Giacobini-Zinner Watch provided support to the International Cometary Explorer (ICE) mission and complements the IHW by using the same ground-based techniques at the same time to study another very different comet for comparison. Individual nets of observers worldwide were organized for each observing technique by eight discipline specialist teams. Overall IHW coordination internally and with flight projects was the responsibility of a Lead Center Organization (LCO) established in Pasadena, CA, USA and Bamberg, FRG, as is responsibility for IHW publications. Advice and oversight protection are supplied by a 29 member steering group. Each flight project interfaces formally with the IHW through a project representative. Amateur contributions were coordinated by the LCO, working through recorders (amateur comet specialist) and existing amateur organizations. The primary archive will be published on compact discs (CD-ROMs). A summary volume on their use and organization and IHW history will accompany the discs. A secondary, printed archive will also be published, if time and funds permit.

W90-70275 **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 such obtained--has been officially endorsed by the International Astronomical Union (IAU). The present investigator (M. B. Niedner) has been selected as a Discipline Specialist (DS) 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.

Planetary Instrument Definition

W90-70276 157-01-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED CCD (CHARGE COUPLED DEVICE) CAMERA DEVELOPMENT
S. A. Collins 818-354-7393

The object of this task is to develop a large-format charge coupled device (CCD) approximately 1024 squared 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. This 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.

W90-70277 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 system. 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 He(High Purity)) are being 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. Development of a gas chromatograph - mass spectrometer for chemical composition measurements of planetary atmospheres will also be carried out.

W90-70278 157-03-70
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY ADVANCED LANGMUIR PROBE TECHNIQUES
L. H. Brace 301-286-8575

The goal of this research is to improve the Langmuir probe technique for future use in the outer regions of the solar system. Past uses of the method have been in the ionospheres of the inner solar system (Earth and Venus) where the large spacecraft photoelectron background limited the measurements to higher densities. The lower solar EUV fluxes at the outer planets will permit the technique to be useful not only in the ionospheres of the outer planets and some of their natural satellites (e.g., Titan) but also in their magnetospheres. To take advantage of this new potential, the sensitivity of the electrometer and the range of the applied voltage must be increased substantially. This research will investigate methods of extending the electronic design to cover the lower density and higher temperature environment of the outer planets. An additional goal is to improve our understanding of the photoelectric yield and secondary electron yield of the collector itself, to permit more quantitative measurements of the solar EUV flux, the energetic ion flux, and the mass distribution of planetary dust particles impacting on the collector.

W90-70279 157-03-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MM2 (MARINER MARK 2) 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, wind angle optics, charge coupled device (CCD) image detector, video data compressor, and square root encoder. The two optical systems were designed, breadboarded and tested in FY-86, FY-87, and FY-88 developmental model (flight mounting configuration) of the narrow angle optics was assembled in FY-89. Also in FY-89, the decision was made to abandon the original wide angle optics design and replace it with a simpler, lighter design having somewhat reduced performance. A baseline design and a contractor were chosen for the CCD detectors, and a contract was issued to build prototype units. The performance of a digital square root encoder was tested in conjunction with actual CCD detector data. For FY-90, the work will concentrate on testing of the developmental model narrow angle optics, detail design of the new wide angle optics, radiation testing of the optical glasses used in the new wide angle optics, and fabrication and test of a breadboard wide angle optics. The prototype CCDs will be built and tested. The instrument development science team will also support NASA Headquarters in evaluation of other proposed facility imaging systems, such as those for the Soviet Mars '94 mission and the Mars Rover/Sample Return mission.

W90-70280 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 (lambda less than 3 micrometer) array detectors. Our objectives are to verify that AOTFs can be qualified for planetary spacecraft experiments and to generate a quantitative data base on AOTF and detector performance upon which we can draw for detailed experiment design, in response to the forthcoming announcement of opportunity for Cassini. Specific issues to be addressed are: (1) tuning range, out-of-band rejection, efficiency, and image quality of a sample AOTF; (2) integrity of AOTFs against mechanical and thermal stresses; (3) near infrared array detector performance; (4) optimum optical configuration for an AOTF-based instrument; and (5) optimum efficiency of RF driver circuits.

W90-70281 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 (LGO). 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 avalanche photodiode (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 polarimeter and spectrometer mode (at 1.06 micrometer) 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. This is a continuation of an RTOP which terminated in FY-89, we propose to continue the development of a Lunar Observer Laser Altimeter (LOLA) to be ready if LGO is given a new start.

W90-70282 **157-04-01**
Goddard Space Flight Center, Greenbelt, MD.
HIGH TEMPERATURE SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID)
C. Allen 301-286-8694

The objective of this project is to develop a Superconducting Quantum Interference Device (SQUID) for space flight use in planetary and interplanetary magnetic field research. The task will develop a SQUID magnetometer using developing technology associated with high temperature-superconducting (HTS) junctions. The goal is to demonstrate the operation of the device at or above 77 K with equivalent sensitivity and low noise characteristics of low-temperature SQUIDs. The SQUID will be designed and fabricated using Goddard in-house capabilities.

W90-70283 **157-04-80**
Ames Research Center, Moffett Field, CA.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM - TITAN ATMOSPHERIC ANALYSIS
G. C. Carle 415-694-5765
(199-52-52; 107-20-08; 157-05-50)

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.

W90-70284 **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 degrees Kelvin at selected, mid-infrared wavelengths (3 to 30 micrometer). 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(-9) 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. For applications to future Mars missions, the emphasis would be in determining the abundances and variabilities (in space and time) of minor gases such as O3 and H2O, to establish isotope ratios of major elements with high precision, and to look for non-equilibrium gases (e.g., CH4, SO2, H2S) indicating biological or geothermal activity.

W90-70285 **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 FY-90 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.

W90-70286 **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 radar sensor which will be a facility science instrument on Cassini for mapping the surface of the largest Saturnian moon-Titan. The surface of this moon is hidden from optical view because of the optically dense haze. The best available optical image of Titan shows a reddish-yellow fuzzy ball with limited scientific value so far as the surface process study is concerned. A radar sensor, on the other hand, offers a unique capability for obtaining unobscured images of the surface, surface topography, and even subsurface penetration data to arrive at a better understanding of the surface processes at work. During FY-90 the development activities will involve detailed design of various subsystems. In the antenna subsystem area, computer simulation results and engineering breadboard test measurements will be generated to better assess the multi-feed antenna performance in actual flight configuration. In both the radio frequency (RF) electronics subsystem and digital subsystem areas, hardware performance and reliability will be assessed, long-lead items will be identified, and some critical modules will be breadboarded. In the system engineering level, end-to-end computer simulation on each of the radar modes will be generated to estimate the performance; and the feasibility of using this radar sensor for remote sensing over other targets of opportunity, such as rainfall measurements on Titan, Saturn rings during Saturn orbit insertion (SOI), other Saturnian satellites, Galilean satellites during Jupiter encounter, and asteroids will be studied.

W90-70287 **157-04-80**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIMISSION VIMS MC2
R. Lockhart 818-354-5468

The objective of this RTOP is to continue the development of the Visible and Infrared Mapping Spectrometer (VIMS) instrument in anticipation of a new start in FY-91; specifically: (1) continue to work with French and Soviet collaboration to complete the preliminary design of Omega VIMS; (2) complete the preliminary

design and start the detail design of Cometary Rendezvous Asteroid Flyby (CRAF)/Cassini spectrometer; (3) complete preliminary designs of electronics; (4) complete the evaluation of CRAF/Cassini Focal Plane Assembly and Design and Fabrication first article of Mars Focal Plane Assembly; (5) complete the preliminary design and detail design of the electrical ground-support equipment (EGSE); and (6) hold preliminary design review.

W90-70288 **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. The first task is a new proposal for the development of a high-resolution fiber-coupled infrared array spectrometer for planets, planetary systems and comets. The infrared array and fiber bundle technology is suitable for earth orbital investigations in missions currently in the planning state. The second task 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. The third task 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 task supports development of the baseline infrared thermal emission spectroscopy experiment for the Cassini orbiter. Another 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

W90-70289 **159-46-01**
Marshall Space Flight Center, Huntsville, AL.
ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
D. C. Cramblit 205-544-0569

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 space transportation system (STS) 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, High Energy Astronomy Observatory-2 Spacecraft (HEAO-2). An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. This RTOP activity will place emphasis on completion of design definition phases of the AXAF program to assure a sound basis for Phase 2 approval in FY-92.

Oceanic Processes

W90-70290 **161-10-00**
Wallops Flight Facility, Wallops Island, VA.
OCEAN ADVANCED STUDIES
C. L. Parsons 804-824-1390

The major objective of this RTOP is to advance the state-of-the-art instrumentation of benefit to ocean color and active microwave remote sensing. In FY-90, this RTOP has the following tasks: (1) to improve our differential Global Positioning System (GPS) navigation capability by adding an 8-channel receiver and upgrading our software accordingly; to develop a mission plan for the detailed mapping of the Gulf Stream using the Multimode Airborne Radar Altimeter (MARA) after its performance verification tests, the enhanced differential GPS system, and archived gravity data and airborne gravimetry measurements; and (3) to continue the definition of the cWiFS ocean color instrument in collaboration with Eostat in preparation for deployment on LANDSAT 6.

W90-70291 **161-10-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED SCATTEROMETRY
F. K. Li 818-354-2849

The general objective of this task is to develop a new airborne scatterometer system that can serve as a research facility for geophysical research as well as a testbed for advanced scatterometer technique and technology that will improve the performance of future spaceborne scatterometers. In FY-90, our specific objective is to perform several selected improvements on the New Airborne Scatterometer (NUSCAT) system and to conduct a second calibration experiment in order to provide absolute radar cross section measurements from NUSCAT. For the NUSCAT improvement activities, we will procure a limited number of spare modules in order to increase the reliability of the system operation during long experiment deployments. The precision attenuator subsystem will be tested through a range of temperature settings in order to assess its loss at the different operation temperatures. We will modify several RF components, especially the calibration loop design, in order to enhance the calibration stability of the system. We will also modify the controller software in order to obtain more optimal gain settings for the cross polarization measurements. At present, we are considering replacing the antenna with one that has better polarization isolation and performing detailed frequency transfer function tests on the replacement unit. These activities will be completed in the first quarter of FY-90 in order to be ready for the Surface Wave Processes Program (SWAPP) deployment. We will also conduct a second sphere calibration experiment in which the cross section of a sphere is measured. This provides a standard calibration target that we can use to measure the end-to-end system gain and the stability of the gain vs time. This second experiment is necessary to provide confidence in the data collected during the SWAPP experiment as well as for experiments in FY-91 such as Surface Wave Dynamics Experiment (SWADE) and the ESA Remote Sensing Satellite-1 (ERS-1) post-launch validation experiment. The calibration experiment will follow closely with the calibration plan that was submitted to NASA Headquarters on the first calibration experiment in FY-89. The second experiment will occur in June and July, 1990, which is mid-way between SWAPP and SWADE.

W90-70292 **161-20-00**
Goddard Space Flight Center, Greenbelt, MD.
PHYSICAL OCEANOGRAPHY
P. S. Schopf 301-286-7428

This RTOP supports the Oceans Program and the end objectives of understanding, predicting and managing the environment. The immediate objective is to conduct research in physical oceanography that contributes to global environmental modelling and remote sensing in terms of earth system dynamics. Continuing tasks within this RTOP include: (1) Atlas -- to add directional information to data products from satellites returning scalar wind speeds only; (2) Busalacchi -- to use upper ocean models to analyze the variability of the tropical Pacific and Atlantic Oceans; and (3) Schopf -- on tropical air-sea modeling, with the

development of near-real time predictive and diagnostic models for global ocean circulation, including the assimilation of altimetric and in situ oceanographic data. Proposals have been submitted for continuance of two efforts: (1) Marsh and Koblinsky -- to estimate mean dynamic ocean topography; and (2) Koblinsky and Marsh -- to analyze large scale variations in sea level.

W90-70293 **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 analyze the deep water tides using Geosat altimetry data and the orbits produced for Geosat by the Goddard Space Flight Center based on the Goddard Earth Model T1 (GEMT1) and Goddard Earth Model T2 (GEMT2) geopotential models. This work will provide a progression relating the improvement in tidal solutions to the improvement in orbit accuracy. A secondary objective will be to estimate the point at which orbit determination is no longer a limiting factor in direct tidal solutions with altimetry data. This will provide an intermediate step towards the high quality tide solutions to be expected from Topex/Poseidon. The general approach will be to cluster altimeter data using three neighboring ascending and three neighboring descending tracks. This will provide additional phase information about the M2 tide. Time differenced data will be analyzed using conventional tidal analysis. There will be no adjustment of the data to remove orbit error. The results will be compared with independent measures of tidal parameters and with Seasat results and other Geosat results.

W90-70294 **161-20-33**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DETERMINATION OF THE EM BIAS IN OCEAN ALTIMETRY
E. Rodriguez 818-354-5668

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 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 actual altimeter returns by parametrizing the dependence of the EM bias on the parameters which can be recovered from the altimeter waveform: the significant waveheight, surface skewness, wind speed, and nondimensional fetch. We estimate this dependence by performing a repeat track analysis using the data from the Geosat altimeter. In addition, we propose in FY-91 to use National Data Buoy Center (NDBC) buoy data collocated with Geosat altimeter waveform data to explore more fully the dependence of the EM bias and the ocean surface skewness on the various geophysical parameters recorded by the buoys, as well as the shape of the wave spectrum. Second, we study the scattering mechanism responsible for the EM bias. The scope of this task was decreased after last year's review. During this year, we have used the analytical scattering theory developed in 1988 to obtain further theoretical insight into the exact mechanism responsible for the EM bias.

W90-70295 **161-25-00**
Goddard Space Flight Center, Greenbelt, MD.
OCEANOGRAPHIC SATELLITE RESEARCH
R. G. Kirk 301-286-7895

This RTOP covers pass through grant money for peer-reviewed ocean science research at universities, as well as support of science working groups.

W90-70296 **161-30-00**
Goddard Space Flight Center, Greenbelt, MD.
OCEAN OPTICS
Charles R. McClain 301-286-5377

This RTOP is designed to develop methodologies that utilize remote optical sensors (airborne and satellite, active and passive) 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. 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 investigations of coupled oceanic physical-biological processes (McClain), the Airborne Oceanographic Lidar (Hoge), ocean color in the Arctic (Maynard), and the Coastal Zone Color Scanner (CZCS) Archive (Feldman). New proposals are for SEAPAK support (McClain), ocean data set archiving at NASA Climate Data System (NCDS) (McClain), and advanced atmospheric corrections for the CZCS (McClain). Elements of this RTOP are closely coupled with the processing of the global CZCS data set which is being undertaken by the Nimbus Project Office.

W90-70297 **161-30-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF OCEANIC PRIMARY PRODUCTION
D. J. Collins 818-354-3473

The objectives of this research are the description of the spatial and temporal variability of the primary productivity of the oceans on season to interannual time scales and the description of the coupling between the phytoplankton populations of the surface mixed layer and the physical environment of the near-surface waters. The approach in this research is to develop models describing the primary productivity of the ocean in terms of the spatial distributions of chlorophyll biomass, incident solar radiation and sea-surface temperature and to use these models to develop techniques for the remote assessment of regional and global distributions of oceanic primary productivity. These models will be used to assess the seasonal and interannual variability of the primary productivity of the Gulf of California, of the Southern California Bight and of the Equatorial Pacific Ocean. These studies are in progress. The approach is to explore physiological relationships between the near-surface concentration of chlorophyll and the primary productivity of the surface mixed layer. The research includes spectral studies of the fluorescence, absorption and scattering of marine phytoplankton, and investigations of the taxonomic and photoadaption effects required to interpret remotely sensed data obtained from the ocean. The research will include the development of biological and physical modeling of the near-surface layers of the ocean for the description of the coupling between the biological populations of the ocean and the physical environment.

W90-70298 **161-30-33**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHYTOPLANKTON DYNAMICS OF THE EASTERN NORTH PACIFIC
C. O. Davis 818-354-5395

This research focuses on the use of Advanced Very High Resolution Radiometer (AVHRR) sea-surface temperature (SST) and Coastal Zone Color Scanner (CZCS) ocean color data for the study of primary productivity and phytoplankton dynamics in highly productive ocean 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 validated with mooring data and coupled with a physical-biological model to extrapolate those results in time and space. Our initial 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. We are reprocessing CZCS data with the latest chlorophyll algorithms and then will use principal component analysis (collaboration with G. Lagerloef) to analyze the correlation of the chlorophyll patterns with physical features from the SST imagery. Beyond this we are using satellite ocean color and SST data in total and new production models and eventually in coupled physical-biological models to obtain regional and basin scale estimates of phytoplankton productivity. This year field work has been extended to include the equatorial Pacific upwelling area,

and the North Atlantic spring bloom. In February and March 1988 optical measurements of phytoplankton chlorophyll and productivity was collected along a transect across the equatorial region at 150 deg W. In April and May 1989 similar data was collected during the North Atlantic spring bloom. In both cases these results will be compared with more traditional measurements 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.

W90-70299 **161-40-00**
Goddard Space Flight Center, Greenbelt, MD.
POLAR OCEANOGRAPHY
R. A. Bindschadler 301-286-7611

The objective of this RTOP 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 activities include: (1) validation of sea ice parameters derived from DMSP Special Sensor Microwave Imager (SSM/I) and ancillary data with special attention given to the 85.5 GHz channel and its application for detection of thin sea ice; (2) modeling and data analysis to better understand the nature of microwave emissions from snow and ice using a combination of surface, airborne and satellite data; (3) investigations of the physical and biological processes which occur in the Arctic oceans; (4) derivation and analysis of a time series of sea-ice concentration maps seeking regional or hemispheric trends which might portend changes in global climate or indicate the nature of interactions between sea ice and either the ocean or atmosphere; (5) use of synthetic aperture radar (SAR) data in studying the damping of ocean waves by sea ice and the variability of the hydrologic cycle on ice sheets; and (6) processing and archiving of satellite radar altimetry data over sea ice and ice.

W90-70300 **161-40-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE/PASSIVE SEA ICE ANALYSIS
F. D. Carsey 818-354-8163

Continued research is proposed in the geophysics of sea ice and in the observations of key ice properties and conditions with synthetic aperture radar (SAR) data. This program includes research into air-sea-ice interactions and into the processing of satellite data so as to be prepared, at time of launch of Earth Observing System (EOS) SAR, to generate from SAR data (and other data if required) geophysically useful data products, e.g., surface fluxes of heat, mass and momentum, over the ice-covered seas and their immediate oceanic environment. Work leading to EOS includes scientific studies of the ice and its adjoining boundary layers, development of methods to extract information in geophysical units from the backscatter images generated by the radar systems, and refinement of these methods for automated use. The first spaceborne data for this application will be that from the European SAR satellite, ESA Remote Sensing Satellite-1 (ERS-1), now planned for launch in 1991. In the immediate future data will be examined from Seasat, LIMEX 1987 and 1989 (Labrador Ice Margin Experiment) and from aircraft programs in May 1987 and March 1988. A proposal to EOS to design and implement a global version of the Geophysical Processing System which is being built for Alaska SAR Facility (ASF) was approved. During the course of FY-90 the relationship of the EOS activities and the research program described in this RTOP must be determined through discussions with appropriate program management. The SAR systems to fly prior to EOS will be valuable sources of data for geophysical research as well as for systems and algorithm development, but they inevitably undersample the polar seas. Within the overall goal of the program, preparation for EOS use in understanding the polar oceans, there are a number of specific tasks. These serve: (1) to better understand the interactions of the ice with its environment and the ice properties controlling those interactions; (2) to clarify the role of observations, especially spaceborne SAR, to the accurate determination of the geophysical fields describing the strengths of these interactions; (3) to develop methods to routinely and accurately process the data, largely SAR images of microwave backscatter, to generate the geophysical fields and archive and disseminate the results; and (4) to organize and update the requirements placed on satellite data sets for optimal use by the polar oceanographic scientific community. Mark Drinkwater from Cambridge is in his second year as Resident Research Associate; he is modeling sea ice backscatter from sea ice, investigating ice rheology and examining polarimetric SAR methods. John Bredow is a NASA graduate student at the University of Kansas. He is comparing aircraft SAR and on-site backscatter data; he will hold his defense of Ph.D. thesis in June, 1989.

W90-70301 **161-40-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA OCEAN DATA SYSTEM (NODS)
D. Halpern 818-354-5327
(656-61-12)

The JPL-node of the NASA Ocean Data System (JPL/NODS) aims to be the U.S. leader in the archive and distribution of satellite ocean data products, emphasizing altimetry and scatterometry. For altimetry and scatterometry data sets (e.g., Topex and NASA Scatterometer (NSCAT)), a wide variety of data, including interim geophysical data records (IGDR), geophysical data records (GDR), metadata and in situ measurements, will be archived. For other data sets (e.g., Advanced Very High Resolution Radiometer (AVHRR) and Special Sensor Microwave Imager (SSM/I) non-frozen ocean data), only higher-level products will be archived. The JPL/NODS has identified several applications urgently needed by ocean scientists: (1) acquire NASA funded and other agency funded higher-level satellite ocean data sets; (2) provide data extraction services and rapid delivery of data; (3) provide user friendly access to information about NODS resources; (4) access via electronic networks to the NASA master directory (NMD) and inventories; (5) provide user friendly inventories to facilitate data granule location and ordering; (6) provide leadership in preparation of CD-ROMs containing single and multi-sensor ocean data; (7) assist the oceanographic community in reprocessing higher-level satellite ocean data sets; (8) continuously update the JPL/NODS oceanographic data base to meet requirements of international research programs (TOGA, WOCE, GOFS, IGBP), especially important for Topex and NSCAT data which will be acquired every month; (9) be the U.S. archive and distribution site for Topex, Poseidon and NSCAT data, and metadata; (10) promote standards for classifying, documenting and archiving data to facilitate access to data; and (11) produce with principal investigators of higher-level data products an annual report of monthly graphical distributions of global ocean variables contained within NODS archive. Five activities will be emphasized in FY-90: data acquisition, data distribution, JPL flight project coordination, CD-ROM production, and inventory development. Geosat, SSM/I, Tiros Operational Vertical Sounder (TOVS), and AVHRR data will be added to the archive. CD-ROMs will be created for volume 2 of the WCTS and for Geosat data. Geosat and AVHRR inventories will be created. An archive and data distribution management plan for Topex will be established. Participation in CEOS, ISSP, TNAWT, CI, AVISO and other workshops, meetings, and committees will continue.

W90-70302 **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 is to develop a geophysical processor system for ice and ocean studies that is capable of automated data processing producing a classification of ice types and an extraction of ice motion parameters from multi-date 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 Japanese Earth Resource Satellite-1 (J-ERS-1), Radarsat and the Earth Observing System (EOS) SAR. The approach is to develop techniques for ice classification, two-dimensional motion tracking and extraction of ocean wave parameters that are both reliable and efficient. Additionally, as part of this task we will 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 and because of the high spatial-temporal variability of sea ice. These characteristics mandate the development of new image processing approaches to the classification and tracking problems. 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; extraction of ocean wave parameters from high resolution image spectra and evaluation and testing of system architectures that are optimal to the implementation of such a system.

W90-70303 **161-45-00**
Wallops Flight Facility, Wallops Island, VA.
CONTRACT ADMINISTRATION OF ASF
G. H. Trafford 804-824-1565

The objective of this RTOP is to establish an Alaska Synthetic Aperture Facility (ASF) at the University of Alaska Fairbanks (UAF) for the reception and distribution of X-band synthetic aperture radar data (SAR) from three non-NASA satellites during the 1990 to 1997 time frame. The ASF is intended to be a turnkey system and be fully operational by the beginning of FY-90. As presently planned, the ASF consists of three primary systems: (1) the receiving ground system (RGS) which acquires raw data from the satellites; (2) the SAR processor system (SPS) which converts raw data into imagery; and (3) an archive and operations system (AOS) which archives raw data, imagery, and coordinates facility activities. The ASF will be operated by the UAF's Geophysical Institute as a research organization. The Institute expects to participate as a full partner in the development of the scientific applications of the data processed at the station and this fact reflects the primary scientific emphasis of the ASF. Its purpose is to support research and although it is not a routine receiving station, 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 dated July 18, 1986, signed by the Administrator.

W90-70304 **161-50-00**
Goddard Space Flight Center, Greenbelt, MD.
PROGRAM SUPPORT
A. J. Busalacchi 301-286-9502

The objective of this RTOP is to provide support for oceanic process research activities.

W90-70305 **161-50-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEANIC REMOTE SENSING LIBRARY
D. Halpern 818-354-5327

The objectives of this program are to: (1) maintain technical library of periodicals, reports and books related to biological, physical and polar oceanography, air-sea interaction and remote sensing technology; (2) maintain circulation procedures; (3) maintain special-collection of NASA, DOD, NOAA, CNES, ESA, NASDA and JPL internal documents related to oceanographic flight projects; and (4) support code EEC/Oceanic Processes Branch research activities, including retrieval of scientific literature. The oceanic remote sensing library collection consists primarily of the following items: periodical journals, (50); periodical newsletters, (4); books, (150); and report/reprints, (300). Milestones for FY-90 are to: determine adequacy of periodical journal collection; increase free-of-charge periodical newsletter collection; and acquire free-of-charge reprint/report collection related to large-scale oceanographic and air-sea interaction programs (e.g., GATE, FGGE, FASINEX, WCRP, EOS, TOGA, WOCE, ICSU, CODE, LIMEX, PIPOR, BIOMASS, SCOR).

W90-70306 **161-50-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEANIC PROCESSES BRANCH SCIENTIFIC PROGRAM SUPPORT
D. J. McCleese 818-354-2317

The objective of this task is to support the NASA Oceanic Processes Branch in the development and use of remote sensing techniques to study physical and biological oceanic processes and their interactions with the atmosphere.

W90-70307 **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 fundamental goals of this project remain unchanged from the previous year. The primary objective is to 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, workstations, and shared peripherals which will be accessible to all members of the group. The need to continually upgrade the capabilities of this Oceanography Computing Network (OCN) is dictated by the ever-increasing size and sophistication of the research projects undertaken by the group. The major components of the OCN have been installed. The approach for this fiscal year is to supplement the system in areas of special need, including: the acquisition of erasable optical disk and 8 mm cartridge tape systems to provide more convenient access to large on-line datasets; a cpu upgrade and the procurement of a second Unix color work-station to provide additional computational capabilities; and an increase in the manpower devoted to the system to provide better service to the OCN users.

W90-70308 **161-80-00**
Goddard Space Flight Center, Greenbelt, MD.
AIR-SEA INTERACTION STUDIES
F. C. Jackson 301-286-5380

The objectives of this RTOP are: (1) to gain a better understanding of the statistical and dynamical properties of ocean surface wind-waves and their role in air-sea exchange processes; (2) to apply this understanding to improving existing microwave remote sensing techniques; and (3) 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 distributions; (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.

W90-70309 **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 the results, the approximations used in computing latent heat flux in ocean numerical models were 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 are being used to study thermal forcing of the sea surface temperature changes during the ENSO episode. Expansion of the methodology beyond the 1980 to 1983 period and outside the central and eastern tropical Pacific will be pursued. DMSP/Special Sensor Microwave Imager (SSM/I) data will be utilized. Atmospheric forcing and sea level changes during the Ocean Storm experiment will be studied. Variabilities of the atmospheric pressure loading and equivalent atmospheric temperature used for altimetric correction will be examined.

W90-70310 **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 was accepted and funded by NSF (15 January 1987); a follow-on proposal is in preparation. The one-dimensional (1-D) shoaling model of Freilich and Guza (1984) is being extended to account for non-normal wave incidence and irregular bottom topography, resulting in a model describing two-dimensional (2-D) shoaling and refraction including nonlinear wave-wave interactions. One-dimensional shoaling models incorporating near-resonant nonlinear wave-wave interactions (Freilich and Guza, 1984) were shown to predict accurately the shoaling transformation. Sufficient field data exist 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, but that near-resonant triad interactions can account for anomalous evolution of the measured frequency-directional spectra, thus supporting the basic physics embodied in the 1-D model of Freilich and Guza. The 1-D model is being extended to 2-D using a parabolic assumption as in Liu, et al., (1985). After tests to validate the numerics and boundary condition assumptions, direct comparisons will be made with data. Model integrations are presently being conducted on the SDSC CRAY.

W90-70311 **161-80-38**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN CIRCULATION FROM SATELLITE ALTIMETRY
L.-L. Fu 818-354-8167

The long-term objective of this RTOP is to investigate the utility of satellite altimetry for studying the general circulation and variability of the oceans. The current focus is Geosat altimeter data. A data processing facility was established to produce an edited, geographically gridded Geosat data set for efficient scientific use of the data. Optimal estimation techniques (objective mapping, Kalman filtering and smoothing) are the main tools for analyzing the data for studying ocean dynamics. Both descriptive and modeling studies were conducted. Following are the near-term objectives: (1) investigation of methods for fitting ocean models to altimeter data -- initial approach is to design a Kalman filtering scheme and apply it to the equatorial oceans; (2) comparison of Geosat observations with model predictions in the Indian Ocean -- main focus is seasonal and interannual variability; (3) descriptive studies of the western boundary currents (the Gulf Stream, Kuroshio, and the Agulhas Current) and the equatorial Pacific Ocean -- main focus is mesoscale eddies and equatorial waves; and (4) continuous production and maintenance of the gridded Geosat data set and delivering the products to NASA Ocean Data System (NODS) for distribution to the oceanographic community.

W90-70312 **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 such as near surface winds through airborne scatterometry experiments. The primary FY-90 objective is to participate in the Surface Wave Processes Program (SWAPP) experiment off the California coast in February and March of 1990 using the new airborne scatterometer (NUSCAT). Preliminary analysis of the data obtained will also be performed. Preparation is being made for the Surface Wave Dynamics Experiment (SWADE) that will occur in early FY-91. The NUSCAT instrument will be integrated on the NASA/Ames C-130 in early 1991 and NUSCAT will be flown in conjunction with the C-band scatterometer (CSCAT) from University of Massachusetts, Amherst, during SWAPP. Seventy flight hours are requested on the C-130. The first 10 flight hours will be used for engineering test flights. The remainder will be used in ten flights over the experiment site. In each flight, about 4 hours of radar backscatter will be collected at Ku-band using NUSCAT and C-band using CSCAT. An attempt will be made to collect data at low wind speed ranges and in cases where the major surface wave systems are not aligned with the wind direction. The NUSCAT results will be processed into relatively calibrated radar cross sections by the end of FY-90. Preliminary intercomparion will be conducted between the Ku- and C-band results, especially the azimuthal modulation depths and the locations of the modulation extrema. Interaction with the SWAPP experiment team will occur to obtain the relevant in situ data. Preparation will be made for the SWADE deployment in early FY-91. A detailed experiment plan for participation in SWADE will be generated.

W90-70313 **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 compare the major western boundary currents as seen with altimetry; (2) to compare altimetry, current meter, and bottom pressure data with a simple inverse model to assess consistency and information content (with D. Luther, Scripps); and (3) to update, add corrections, and continue release to interested oceanographers of the working global data set developed at JPL. Several methods to monitor western boundary current surface intensity will be compared, and after settling for one, the Gulf Stream, Kuroshio, Brazil, and Malvinas (Falkland) currents will be intercompared to assess seasonality, etc., from over two years' worth of Geosat data. Using a simple linear stratified model and inverse methods, the consistency of the model and the various data types will be assessed. Generation of the working gridded data set will continue as presently done and new wet tropospheric (Emery, 1989) and orbit (Hayes et al., 1988) corrections will be added. The principal investigator will devote 80 percent time to these tasks. The remaining 20 percent time will be devoted to the Topex project (10 percent) and to the World Ocean Circulation Experiment (10 percent), as well as to the Geophysical Data Committee of the National Research Council. Funds are also requested for a summer student and to purchase meteorological data from the European Centre for Medium Range Weather Forecast.

W90-70314 **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. Glazman 818-354-7151

Analyses of errors in wind speed measurements by microwave remote sensing instruments, i.e., by scatterometer, radiometer and altimeter, have been reported in our recent papers demonstrating that errors in virtually all satellite instruments are considerable and they exhibit certain geographic trends. Since the error biases responsible for such trends are ultimately caused by environmental factors, it is important to interpret these trends in terms of statistical characteristics of sea surface geometry and, eventually, improve the geophysical model functions for satellite measurements. The general objective for FY-90 is to improve the interpretation of the altimeter measurements of radar cross sections and waveforms. The approach undertaken in our work combines theoretical results on microwave backscatter reported in our recent papers with empirical data obtained from Geosat altimeter measurements. The specific objectives are: (1) to develop a new geophysical model function for wind speed estimation from altimeter measurements, accounting for the actual degree of wave development; (2) to study basic parameters of the equilibrium wave spectra of developed seas as functions of wind speed and of sea maturity; and (3) to improve the interpretation of altimeter waveforms on the basis of recent theoretical and experimental results on both near-nadir backscatter and sea surface statistical geometry.

W90-70315 **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.

W90-70316 **161-80-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE OCEANOGRAPHY
W. C. Patzert 818-354-4199

This research is aimed at improving techniques for the utilization of the spaceborne data that is anticipated from the NASA Scatterometer (NSCAT) and the U.S./French Topex/Poseidon altimetric missions. Eventually, the techniques developed in this research will be applied to the scientific utilization of the future scatterometer and altimeter data that will also be required for the international Earth Observing System later in the decade. Analyses will be continued with the altimetric data now available from the U.S. Navy Geosat mission and the TOGA Sea Level Center data from the Pacific Island network. For the Geosat data, the objective is to use altimetry data to document and study storm surges along the coastal regions of the northern Indian Ocean. Information was received about 8 events in the Bay of Bengal, Arabian Sea, or along the east coast of India for 1987, and another 5 events in 1988. More detailed information describing the locations and times of these events has been requested from colleagues in Bangladesh, Pakistan, and India. In collaboration with Tim Liu, a study has been initiated to calculate the response of local sea level to the loading of atmospheric pressure, the inverted barometer effect. The approach will be to calculate the correlation, at various frequencies, between the sea level and locally measured atmospheric sea level pressure. The eventual 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 in order to correct for the inverse barometer effect on the local calculation of sea surface topography. In summary, the near-term plan is to devote my efforts to the development of techniques for the scientific analysis of available altimetric and sea level data with the long-term intent of preparing for the future flights of NSCAT and Topex/Poseidon. This RTOP covers one-half of my time, the other one-half being shared by my JPL duties as Acting NSCAT Project Scientist, and Co-Investigator on the Topex/Poseidon and EOS Interdisciplinary Science Teams.

Space Physics SR&T

W90-70317 **170-10-10**
Ames Research Center, Moffett Field, CA.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
A. Barnes 415-694-5506

The objective of this RTOP is to improve our understanding of the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. The approaches of this RTOP are to conduct theoretical studies 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.

W90-70318 **170-10-10**
Goddard Space Flight Center, Greenbelt, MD.
COSMIC AND HELIOSPHERIC PHYSICS
R. Streitmatter 301-286-5705

The objective is to study the properties of the galactic and solar cosmic radiation in order to understand their origin and propagation in galactic and solar system magnetic fields, and to study the properties of the space plasmas in which acceleration takes place. The particles observed are the nuclear and electronic spies: their energy spectra, their charge states 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 small and large Explorer class spacecraft. Many heavier, larger-area payloads require large space platforms such as the Space Station or Polar Platforms. There is

also a large effort directed at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments 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.

W90-70319 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
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 emulsion chambers 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) apply three-dimensional hadronic-electromagnetic cascade simulation of X-ray film spots and scanning microdensitometry to measure primary energy and produced particle transverse momentum; (2) develop computer assisted techniques for microscope measurement of composition and interaction data in emulsion chambers; (3) 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; and (4) investigate the background in emulsions and X-ray films induced by the ambient space radiation.

W90-70320 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
MHD STUDIES IN SPACE PLASMA THEORY: CORONAL AND INTERPLANETARY PHYSICS
S. T. Suess 205-544-7611

We are developing analytical, numerical, and empirical models while studying magnetohydrodynamic waves, the heliospheric termination shock, and the morphology and phenomenology of coronal and interplanetary magnetic fields. Our studies of MHD waves 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 are modeling its asymmetry due to the Bernoulli effect, predicting this asymmetry at the heliographic latitude of Voyager 1, taking into account solar wind mass flux spatial dependences and variations with solar cycle, and considering possible dynamic time-dependent effects. With regard to coronal and interplanetary magnetic fields, we are conducting 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.

W90-70321 **170-10-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSMIC AND HELIOSPHERIC PHYSICS
E. J. Smith 818-354-2248

This RTOP consists of six subtasks: (1) Magnetospheric and Interplanetary Data Analysis (#170-10-10-89, E. J. Smith); analysis and interpretation of Pioneer, ISEE vector helium magnetometer data and ISEE plasma wave data. (2) Radio analysis of Interplanetary Scintillations (#170-10-10-91, R. Woo); probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of spacecraft radio signals. (3) Solar Wind Data Analysis (#170-10-10-88, M. Neugebauer); investigations of heliospheric physics, including the acceleration of the solar wind and stream-stream interactions, using solar wind data acquired by past missions. (4) MHD processes in the Solar Wind (#170-10-10-86, B. E. Goldstein); theoretical analysis of wave and shock processes in the solar wind. (5) Propagation of Solar Wind to the Outer Heliosphere (#170-10-10-85, J. Feynman); 2-D MHD modeling of propagation of solar wind disturbance. (6) Giotto Solar Wind Data Analysis (#170-10-10-87, R. Goldstein); investigation of heliospheric physics, using Giotto ion mass spectrometer data.

W90-70322 **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, such as: the study of coronal structures that relate to the solar wind and inter-planetary plasma; the study of the sources of high-energy solar-flare particles; and 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: a stigmatic EUV spectrograph to observe coronal features with high spatial and spectral resolutions; a high-resolution imaging system for measuring the spatial, spectral, and temporal characteristics of hard X-ray emissions from solar flares; and a novel device to make high precision measurements of the sun's diameter and its variations with time. Another task 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, including high speed data acquisition systems, multi-layer optical coatings, and two-dimensional hard X-ray detectors.

W90-70323 **170-38-51**
Marshall Space Flight Center, Huntsville, AL.
MAX '91 SOLAR BALLOON PROGRAM
John M. Davis 205-544-7600

NASA Headquarters has recognized the unique opportunity for obtaining scientific observations at the next solar maximum from instruments flown to balloon altitudes (120,000 ft) for extended periods of time (15 to 30 days). These observations require an accurate (1.0 arc min) and stable (10 arc sec/sec) solar pointing system. Such a system is not in the current inventory and must be developed. The Marshall Space Flight Center possesses the necessary skills to manage the development of an accurate and stable point control system and proposes to acquire, using in-house personnel and with the assistance of an outside contractor, two gimbal/gondola systems that will satisfy these requirements. Three scientific instruments have been selected for flight as part of the Max '91 Initiative. These instruments are a Gamma Ray Imaging Detector (GRID), Dr. Carol Crannell, GSFC, Principal Investigator; a Solar Optical Universal Polarimeter (SOUP), Dr. Theodore Tarbell, LMSC, Principal Investigator; and a High Resolution Gamma Ray and Hard X-Ray Spectrometer (HIREGS), Dr. Robert Lin, University of California at Berkeley, Principal Investigator. The SOUP and HIREGS investigations will be managed and funded through MSFC. The program for each instrument will consist of a test flight to take place in FY-91 and a long-duration flight in FY-92.

W90-70324 **170-38-51**
Marshall Space Flight Center, Huntsville, AL.
CONTROLS, ASTROPHYSICS, AND STRUCTURES EXPERIMENT IN SPACE
John M. Davis 205-544-7600
(188-46-01)

Controls, Astrophysics, and Structures Experiment in Space

(CASES) is a joint initiative of MSFC and LaRC for the study of the behavior of large structures in space within the framework of the Controls Structures Interaction Program of OAST. Through the use of a 32 m extendable boom mounted to the STS, CASES will study the pointing, slew and figure control, and the vibration suppression of flexible bodies, while pointing a hard X-ray imaging telescope at both the sun and a celestial target. A strawman scientific program of observations and analysis has been suggested. This program together with the instrument design, including both optics and detectors, will be reviewed by a ten member Science Working Group (SWG), which was selected by NASA Headquarters in March 1989. This evaluation will be required in early 1990 in order to support the CASES Phase C/D contractor selection. Beyond this the SWG will monitor the development of the CASES facility with particular emphasis on maintaining the integrity of the scientific objectives. The SWG will remain in existence until approximately 1 year prior to launch which is currently scheduled for May 1993. The activities of the SWG will be supported through this RTOP.

W90-70325 **170-38-52**
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 flight missions such as the Solar Maximum Mission (SMM), the Gamma-Ray Observatory (GRO), and Long-duration balloon flights, (2) to support operational planning for spacecraft experiments and cooperative campaigns to observe solar activity, and (3) to conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions.

W90-70326 **170-38-52**
Marshall Space Flight Center, Huntsville, AL.
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.

W90-70327 **170-38-53**
Marshall Space Flight Center, Huntsville, AL.
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 Solar and Heliospheric Observatory (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.

W90-70328 **170-38-53**
Marshall Space Flight Center, Huntsville, AL.
UNDERSTANDING OBSERVED 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 Marshall Space Flight Center 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, solar and heliospheric observatory and OSL, and for the balloon program of Max '91. The following studies will be pursued: (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; and (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.

W90-70329 **170-38-53**
Goddard Space Flight Center, Greenbelt, MD.
THEORY, LABORATORY AND DATA ANALYSIS FOR SOLAR PHYSICS
Gordon D. Holman 301-286-4636

The primary objective of this RTOP is to support the laboratory's on-going programs by developing techniques for the interpretation of solar data. The primary goal is to correctly interpret the nature of observable solar phenomena by understanding the fundamental physical processes. This involves obtaining an understanding of the conversion of mechanical energy associated with photospheric velocity fields into a nonthermal energy flux, the propagation of this nonthermal energy from its point of generation to the chromosphere and corona, and the release of this energy in the chromosphere and corona. The focus is on the following areas: (1) the calculation of atomic transition probabilities and studies of nuclear and atomic collision processes in solar plasmas; (2) the development of techniques for determining the strength and structure of the solar magnetic field, from subphotospheric to coronal; (3) determining the physical processes responsible for the conversion of mechanical energy to coronal heating and the driving of the solar wind; (4) determining the physical processes responsible for heating, particle acceleration, and transport in solar flares; and (5) the consolidation of the above processes into models that predict new solar phenomena and explain those already observed. This work utilizes observations of the sun across the entire electromagnetic spectrum, from radio frequencies to gamma-rays.

W90-70330 **170-38-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR PLASMA MODELING AND MEASUREMENTS OF COLLISION PARAMETERS
R. Goldstein 818-354-0241

The first task addressed by this RTOP concerns coronal magnetic reconnection models. The purpose of this task is to determine whether short wavelength magnetohydrodynamic (MHD) turbulence develops during forced reconnection in the corona and whether such MHD turbulence can lead to a significant enhancement of the resistivity, and hence the magnetic reconnection rate, over the values calculated using classical collisional resistivity. One-, two-, and three-dimensional numerical models, coupled with analytic theory, will be used. The goal is to

determine whether such an enhanced reconnection rate can explain the very high plasma heating rates and temperatures observed in the corona, and, in addition, to investigate whether this processes plays a role in more violent coronal events such as flares. A second task addresses solar plasma diagnostics. The purpose of this task is to measure electron-ion excitation collision strengths needed to interpret solar plasma properties such as electron density and temperature. Use is made of the electron-energy loss method pioneered by us at JPL, using merged electron and ion beams, trochoidal energy analysis, and spatial detection of electrons using a microchannel plate.

Mesoscale Atmospheric Processes

W90-70331 **175-13-00**
Goddard Space Flight Center, Greenbelt, MD.
MESOSCALE ATMOSPHERIC PROCESSES RESEARCH PROGRAM
F. Einaudi 301-286-6786
(175-12-00)

The objectives of the Mesoscale Atmospheric Processes Research Program are to: (1) utilize space observations to improve understanding, diagnosis, and prediction of mesoscale processes, with particular emphasis upon precipitating convective systems, their initiation from scale interactions, and intensification to produce severe weather; (2) develop analysis techniques using data from satellites in combination with other sources; (3) adapt subsynoptic- and storm-scale numerical models to use satellite and conventional data; (4) simulate impact of space measurements on analyses, prediction of mesoscale circulations, severe thunderstorms, and their rainfall; (5) develop algorithms for microwave sensing of precipitation from space using cloud models together with aircraft and other data; (6) increase understanding of role of ocean, surface soil moisture, fluxes, and troposphere-stratosphere interactions on storm and precipitation structures; (7) investigate the role of gravity waves in the mass/momentum adjustment process that can also act to initiate cloud and severe storm systems; and (8) help formulate requirements for future space observations of precipitating convective systems. Quantitative methods will be developed to utilize satellite data in predictive models, diagnostics, and nowcasting. The use of satellite and aircraft data sets, often with model output will continue to improve physical understanding and predictive capability. Combined satellite, remote aircraft, and in situ data sets from GALE, COHMEX, and other field programs will be analyzed. Numerical storm-scale and mesoscale models to use satellite data in initialization, model improvement, and data interpretation. The expected results are: more effective use of current and future space data in understanding and prediction of mesoscale and storm-scale phenomena; improved rainfall retrievals from multi-channel microwave instrument overflights by satellite and aircraft; model simulations improved by utilizing combined satellite and conventional data sets; and improved space diagnoses of development of tropical and extratropical storm systems, including their intensity motion, and production.

W90-70332 **175-40-70**
Marshall Space Flight Center, Huntsville, AL.
REMOTE SENSOR DEVELOPMENT
J. E. Arnold 205-544-1646

The objective of this RTOP is 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. Utilizing the talents of university and private 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.

W90-70333 **175-50-00**
Marshall Space Flight Center, Huntsville, AL.
MESOSCALE PROCESSES RESEARCH SUPPORT
G. S. Wilson 205-544-1628

The objective of this RTOP is 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. Utilizing the talents of university and private 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.

W90-70334 **175-90-10**
Marshall Space Flight Center, Huntsville, AL.
EARTH SCIENCE GEOSTATIONARY PLATFORM
G. S. Wilson 205-544-1628

The objective of this RTOP is to establish the science and mission requirements for the Earth Science Geostationary Platform (ESGP) including mission concepts and instrument complement and study for the new EORSF facility. The ESGP Science Steering Committee will conduct mission definition studies and Phase A instrument studies responsive to the Science Requirements from Geostationary Orbit including new facility requirements.

Tropospheric Air Quality

W90-70335 **176-00-00**
Langley Research Center, Hampton, VA.
TROPOSPHERIC CHEMISTRY PROGRAM
James M. Hoell, Jr. 804-864-5826

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.

W90-70336 **176-10-03**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL TROPOSPHERIC MODELING OF TRACE GAS DISTRIBUTIONS
Michael Prather 212-678-5625
(176-10-12)

The objectives are: (1) to contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of human impact on atmospheric composition; and (2) to determine measurement requirements and sampling strategies for tropospheric chemistry program, and aid in interpretation of observations. Three-dimensional studies of trace gas distributions will be made in cooperation with McElroy/Wofsy (Harvard Univ.). A progressive series of studies of trace gases will be conducted: chlorofluorocarbons (source know, 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. A 3-D model will be used to support field programs and identify sources from global/regional observations. Trace gas transport will be coupled to dynamics and physics (including parameterizations) in GCM. It is expected that the OH content of the troposphere will be determined to be consistent with observations of trace gases. Three-dimensional chemical tracer models will be validated for further predictive studies.

W90-70337 **176-10-17**
Goddard Space Flight Center, Greenbelt, MD.
TROPOSPHERIC PHOTOCHEMICAL MODELING
A. M. Thompson 301-286-2629

The objectives of this RTOP are to: (1) analyze field data (including NASA/GTE/ABLE and precipitation) to derive ozone budgets in the troposphere and develop parameterizations of random atmospheric processes for global models; (2) predict perturbations to tropospheric CH4-CO-NO(x) and O3-OH with a photochemical model. The approach consists of: combining modeling and data analysis to derive ozone and other photochemical budgets from detailed study of individual events from field experiments (modeling uses 0-D and 1-D models); and (3) using 1-D and 2-D diagnostic models for multiple runs based on alternative scenarios, to evaluate perturbations and uncertainties in ozone and OH. The expected results include: better understanding of O3, NO(x), CO photochemistry and transport in the boundary layer; and projected trends of tropospheric OH, methane, ozone, CO and NO(x) and interactions with stratospheric ozone.

W90-70338 **176-20-00**
Ames Research Center, Moffett Field, CA.
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 platforms (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.

W90-70339 **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, 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.

W90-70340 **176-40-00**
Ames Research Center, Moffett Field, CA.
MEASUREMENTS OF TRACE CHEMICALS IN THE TROPOSPHERE
H. B. Singh 415-694-6769

The objective of this program is to provide laboratory development of measurement techniques and their application to atmospheric measurement in support of the broader goals of the Global Tropospheric Experiment. The approach involves development and testing of airborne instrumentation and its application to field experiments.

Solar Terrestrial and Astrophysics SR&T

W90-70341 **188-41-01**
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 the 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 instrument 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 star formation in galaxy mergers.

W90-70342 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INVESTIGATING RELATIVITY PARAMETERS WITH LUNAR LASER RANGING DATA
X. X. Newhall 818-354-0000

An expression allowing a departure of the motion of the lunar perigee from the rate predicted by geodetic precession of general relativity was formulated and implemented. When estimated using lunar laser ranging (LLR) data, this postulated excess rate was found to be consistent with general relativity to within 2 %. New LLR data were included in the solution process, and refined estimates for all relativity parameters were made. The estimates of all relativity parameters, including beta, gamma, G(dot)/G, geodetic precession excess rate, and (M(sub G)/M(sub I))earth (the ratio of the earth's gravitational mass to its inertial mass), have been confirmed to be consistent with general relativity to within 2 percent. Investigation of the relativity parameters will continue, employing: (1) the refinement of all dynamical models affecting the computation of lunar range; (2) the continuing inclusion of new LLR data as they become available; and (3) a further, refined joint solution with planetary data, producing a new relativistically consistent lunar and planetary ephemeris. This effort exploits the continuing improvement in the accuracy of LLR data to support NASA's program of research in solar-system relativity.

W90-70343 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GROUND BASED RADAR SUPPORT FOR RELATIVITY
R. F. Jurgens 818-354-4974

New ranging observations of Mercury were made in January and May-June following the upgrade of the 70 m antenna. Most observations were made at 3.5 cm wavelength; however, several were scheduled jointly with Arecibo at 12.5 cm. The improvements in the antenna system have increased the sensitivity of the radar by about 4 dB yielding more accurate measurements and better coverage in longitude than previous observations. Data processing is complete for the 1988 data, and preliminary results are available for the first half of this program. Preliminary analysis of the 1986 to 1987 Mercury data combined with earlier 1966 to 1974 observations indicates that the data are of high quality, and that significant improvement of the ephemeris results even without closure imposed. The formal solution for omega(dot) is 42.985 + or - 0.029 arcsec per century, and G(dot)/G is (0.34 + or - 0.24) x 10(exp -11) per year when measured in atomic units. This program provides highly accurate ranging observations of Mercury for ephemeris development and tests of the general theory of relativity. Data processing of the CY-89 data will be completed, and new

observations are planned for January, May, September and December of CY-90. With these observations in hand, enough closure points will be available for a preliminary solution.

W90-70344 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAVITATIONAL WAVE ASTRONOMY AND COSMOLOGY
F. B. Estabrook 818-354-3247

We have stimulated, monitored, and assisted in the planning for improvements in the Deep Space Network stability and Doppler measuring techniques. We have performed research on techniques for gravitational wave (GW) detection, both response functions and signal processing of Doppler data: to discriminate against phase noise due to propagation inhomogeneities, to utilize 3-way data (when a remote station simultaneously receives the downlink from a spacecraft), and to cross correlate data simultaneously taken from two spacecraft. We have done theoretical research in differential geometry, and new methods of solution of sets of nonlinear partial differential equations, for application to soliton physics, and, in particular, to the nonlinear equations of gravitational wave sources. The response of multipass interferometric GW antennas was considered and reformulated in terms of sideband generation. Exterior differential systems were formulated for a number of sets of partial differential equations of importance in theoretical gravitation: the Einstein vacuum equations, self-dual 4-geometry, Einstein-Maxwell theory, etc. A large class of spinor prolongations has been found, and Backlund transformations are being sought. In FY-90 the above planning and research activities will continue. The new geometric formulation of moving frame analysis will be applied to the theory of rigidly rotating self-gravitating fluid spheroids.

W90-70345 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SIGNAL PROCESSING FOR VLF GRAVITATIONAL WAVE SEARCHES
J. W. Armstrong 818-354-3151

A method for efficiently processing data to search for massive coalescing binaries has been developed and tested on Pioneer 11 data. The approach is computationally simple and robust to data gaps. It exploits the three-pulse response of a gravitational wave to the Doppler observable; after processing, the signal resolves into three sinusoids, which can be efficiently processed to estimate signal amplitude, frequency, and frequency derivative. A program has begun to calculate the sensitivity improvement for these waves when two simultaneous spacecraft observations are made (as will be possible in spring 1993 using the Galileo and Mars Observer spacecraft). A computationally-efficient method of matched filtering for bursts in large data sets having colored noise was developed. A very long (10 day) Pioneer 10 data set was obtained in December 1988 to serve as a test-bed for analysis methods. Massive coalescing binaries produce gravitational waves which, in the millihertz band accessible to spacecraft Doppler experiments, are well-approximated as chirps--sinusoids having frequency increasing with time. There is active theoretical interest in these sources, particularly since it has been recognized that measurement of the strain amplitude, frequency, and frequency derivative give unambiguous distance to the source (independent of masses) and a prediction for the time to coalescence (hence prediction for when a gravitational wave burst should be observed). A computationally efficient scheme to search for these waves in Doppler data has been developed, which exploits the three-pulse response to gravity waves. After processing, one gets estimates of amplitude, frequency, and frequency derivative from which distance and time-to-coalescence estimates can be made. From an observational viewpoint, such waves are very attractive because they are potentially self-confirming--waves from this class of source can be observed with predictable parameters in data sets taken by spacecraft in different years. Future goals are: (1) survey for burst radiation using realistic pulse shapes and exact matched filters based on the noise autocorrelation function using Pioneer 10 and 11 data; (2) extend coalescing binary analysis procedure to two-spacecraft simultaneous observations problem (special emphasis on Galileo/Mars Observer Missions (GLL/MO) opportunity in spring 1993); and (3) study applicability of coalescing binary analysis procedure to interferometric gravitational wave detectors (e.g., microwave or laser interferometers) in space.

W90-70346 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OBSERVATIONAL TESTS OF RELATIVISTIC GRAVITY
R. W. Hellings 818-354-3192

The purpose of this research is to test for the various effects of relativistic gravitation in the dynamics of the solar system. The results of these studies provide the experimental basis for the General Theory of Relativity. In these tests, least squares fits are performed in which all available solar system astrometric and radiometric data are fit to a relativistic model of the solar system. In this last year, I prepared for the analysis of data to be acquired as a result of a collaboration with the Soviet Union in a Phobos Lander mission, but the disappointing loss of the Phobos spacecraft cut these plans short. I have pursued a program of intercomparison of Viking range data with colleagues at the Harvard-Smithsonian Center for Astrophysics. This will lead to an Astronomical Journal paper publishing these ranges during the next year. In addition, a six-year set of timing data from the millisecond pulsar PSR 1937+21 has been acquired from J. Taylor of Princeton University and preparations have begun for analysis of these data in conjunction with other solar system data. Finally, a paper with Carrick Talmage of Purdue University on limits on a long-range fifth force using solar system data appeared in Physical Review Letters. The last Soviet Phobos spacecraft was lost in March of this year, ending plans to improve the determination of a possible time variation in the gravitational constant. The demise of the Phobos spacecraft adds to the importance of participation in the Mars Observer mission in order to attain these same scientific objectives. In FY-90, I will investigate this possibility more fully. Also, studies related to future missions will be continued. A paper on the Viking range data will be completed and published. Analysis of the new pulsar data will be completed.

W90-70347 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPECTRUM OF THE CONTINUOUS GRAVITATIONAL WAVE BACKGROUND
R. W. Hellings 818-354-3192

The purpose of this research is to support the NASA gravitational wave detection program by clarifying the interface between theory and observation. Since the most important result of these experiments will most likely be the measurement or limitation of the gravitational wave background, it is important to understand how strong that background could possibly be and what the cosmological implication of detection or non-detection are. In the last year, I have pursued a program of pulsar data acquisition in collaboration with French colleagues at the Bureau des Longitudes and the Observatoire de Meudon and with J. Taylor of Princeton University. The pulsar data will set the best limits on the strength of the gravitational wave background at periods of weeks to years. Theoretical studies with R. Zimmerman of the University of Oregon have investigated probable sources for low frequency gravitational waves. In addition, a study of a spaceborne microwave interferometer for use in gravitational wave detection continues in collaboration with A. J. Anderson of the University of California, Santa Barbara. Six years of data from the millisecond pulsar PSR 1937+21 were acquired from J. Taylor of Princeton University. These data have an observable long-period residual in them, indicating that the need has now arisen to adjust the solar system parameters in order to fit the data. In the coming year, I will pursue the collaboration with the French in acquiring data from a regular monitoring program for millisecond pulsars. I will analyze the post-fit residuals of the millisecond pulsar data from the solar system parameters adjustment and determine what limits may be set on the gravitational wave background using these data. Finally, I will pursue the study of the microwave interferometer mission.

W90-70348 **188-41-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL STELLAR INTERFEROMETRY
M. Shao 818-354-7834

The Mark 3 interferometer is a long-baseline two-element stellar interferometer with two 12-meter baselines for astrometry, and a variable 3- to 32-meter baseline for stellar diameter and binary star observations, operated jointly with the Naval Research Lab and the U.S. Naval Observatory. The Mark 3 instrument is an important testbed for development of future space-based interferometers. Examples of much of the hardware, active systems and software needed for a space-based interferometer are in use on the Mark 3. In addition, the observational experience gained with the Mark 3 is valuable for establishing the science goals for a space-based instrument. Observations were made for wide-angle astrometry, measurements of stellar diameters and determination of binary star parameters. Results of the observations include: the attainment of 6 milliarc second formal errors in declination for a wide-angle data set using the two-color method; the determination of the diameters of approximately 20 stars, including a cephied variable; the determination of the orbital parameters and masses for beta Ari, a binary previously unresolved by speckle interferometry. Full-time observations with the Mark 3 instrument will continue. Data from the previous year will be used to tune the observing schedule to include, for example, observations of selected binary stars near periastron, and repeated observations of selected objects to demonstrate astrometric repeatability and to examine diameter variations.

W90-70349 **188-41-23**
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
George Sonneborn 301-286-3665

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 testing, mirror technology, and diffraction grating technology. Investigations are presently be conducted in 2 technical areas that will have substantive cost/performance pay-offs. In optical materials research, major emphasis was placed on ultraviolet mirror coating developments for improved system throughput. In the area of diffraction grating technology, studies are being conducted on advanced design, fabrication, and testing methods.

W90-70350 **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 photo-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. Methods of UV enhancement will be explored by Lockheed Corp., Textronix, Inc., 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. Ball Aerospace Systems Group (BASG) will develop hybrid circuitry for use in a miniaturized 1024 x 1024 square pixel MAMA detector.

W90-70351 **188-41-51**
Goddard Space Flight Center, Greenbelt, MD.
UV ASTRONOMY AND DATA SYSTEMS
A. V. Sweigart 301-286-6274

The objectives are: to perform theoretical and observational astronomical research of particular interest for space observations; 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 to support an optical telescope observatory for testing research ideas for space projects; and to develop new instrumentation for observing astronomical objects. The approach is to: (1) obtain detailed stellar evolutionary models for interpreting space observations, particularly those to be made with the Hubble Space Telescope; (2) develop suitable instrumentation for and maintain the NASA/GSFC 36-inch telescope (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); (3) develop and use imaging systems to detect fainter emission-line astronomical objects than currently possible; (4) perform appropriate ground and space observations to study stars, nebulae, the interstellar medium and extragalactic objects; (5) develop tools and techniques for using astronomical data bases (incorporate new astronomical data sets and maintain currency of the databases via journal searches).

W90-70352 **188-41-53**
Goddard Inst. for Space Studies, New York, NY.
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.

W90-70353 **188-41-53**
Goddard Inst. for Space Studies, New York, NY.
STELLAR EVOLUTION AND PULSATION
Richard B. Stothers 212-678-5605

The general objectives are to achieve a better understanding of the evolution of massive stars from the main sequence to the pre-supernova state and to establish more firmly those properties of Cepheids and Cepheid-like variables that are useful for stellar evolution studies and for galactic and extragalactic distance studies. Applications in progress are expected to produce improved information on the extent of convective core overshooting in bright stars both on and off the main sequence. Massive stars and Cepheid variables are useful focuses of study because of their crucial importance in various problems in galactic and extragalactic research. A combination of theoretical numerical modeling and of comparison of the models with observed stars is the main approach being adopted. The fully nonlinear equations of quasistatic evolution and of hydrodynamical pulsations are applied to calculate the models and thus to predict the surface properties that can be compared with observations.

W90-70354 **188-41-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRON IMPACT CROSS SECTIONS OF ASTROPHYSICAL INTEREST
J. M. Ajello 818-354-2457

JPL has completed high resolution electron impact emission studies (0.03 nm) of H Ly(alpha) from dissociative excitation of H2 and of N II resonance lines from dissociative excitation of N2. Models from threshold to 10 KeV have been developed and results compared to ab initio theory, collisional equilibrium models and experimental data. Low resolution (0.5 nm) VUV (visible ultraviolet) spectra have been obtained for H2, NO, SO2 and Ar from threshold to 0.4 KeV. Extreme ultraviolet (EUV) calibration technique was developed for space instrumentation and applied to Galileo UVS and EUV instruments. The highest resolution electron impact induced EUV spectrum of N2 has been obtained from 60 to 135 nm. A remarkably strong spin changing intercombination transition in N II has been observed by comparison to the electric dipole branching transition. Calculation of astronomical collision strengths for N II in collisional equilibrium models must include configuration interaction. JPL plans to make low energy (10 to 100 eV) studies of cross sections of Lyman series of H using newly acquired H-atom radical source. The measurements will be carried out on a high resolution (0.01 nm) spectrometer capable of resolving structure to an arbitrarily high principal quantum number. The threshold measurements of H2 will be completed and models developed for resonance, direct excitation and optically forbidden transitions of importance to electron excitation of VUV radiation in H, H2 and He in cosmically abundant neutral gas clouds.

W90-70355 **188-41-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COLLISION AND OSCILLATOR STRENGTHS
S. Srivastava 818-354-3246

Photoabsorption cross sections were generated in the wavelength range of 100 A to 4000 A for NH3, CH4 and C2H2 by the method of high energy electron impact spectroscopy and a paper was submitted to the Astrophysical Journal. Electron impact ionization and dissociative ionization cross section data (obtained during the last fiscal year for the following molecules: H2, D2, Ne, Ar, Kr, Xe, N2, N2O, O2, CH3OH and C6H6) were analyzed and papers were written. Data on the lifetimes of selected excited states of the following species were analyzed by computer fitting to a two component decay formula: N II, N I, C I, O I, S I, S III, CO, CS I, and CS2. Dissociative attachment cross sections for the following species were measured: NO (published), N2O (submitted) and C6H6. Efforts to successfully utilize the Nd:YAG laser for obtaining oscillator strength data are in progress. A technique was developed for calibrating the mass dependent transmission efficiency of a mass spectrometer and a US patent application was submitted. The goals of this RTOP will be to: (1) utilize the Nd:YAG laser to measure lifetimes of selected excited states of O I, C II, N II, Mn I, Mn II, S I, S II, Fe II, C II, and Si II; (2) obtain photoabsorption cross sections for H2, N2, CO, NO, H2O, H2CO, HCN, NO2, SO2, CS2, OCS, H2O2, H2S, H2O, and other hydrocarbons; and (3) obtain dissociative ionization and attachment cross sections for HCN, C2H2, CS2, OCS, NH3, C2H2, H2CO, H2S, and a large number of hydrocarbons which are found in the interstellar clouds and comets.

W90-70356 **188-41-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRON COLLISION CROSS SECTIONS
S. Trajmar 818-354-2145

A critical review of electron-H2 collision data was published. A similar review on atomic hydrogen is in progress and almost completed. A new technique developed for low-energy electron impact cross section measurements was devised and published. Electron collision measurements on CO have been completed and are being evaluated. The expansion cooled molecular beam source for polycyclic aromatic hydrocarbons (PAH)-electron collision measurements was designed and built. Efforts are coordinated with modelers of interstellar medium. A critical review on the status of electron-H2 collision processes was published. The review on electron-H collision processes will be published. The electron-CO results will be evaluated and published. Measurements on electron impact excitation of PAH molecules will start as soon as the turbo pump is repaired. The design and construction of intense ion beam source will continue.

W90-70357 **188-41-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRON-ION COLLISIONS
A. Chutjian 818-354-7012

Accomplishments in the past 12 months were: (1) successfully reduced backgrounds of electrons and ions on our position-sensitive detector (PSD) to the 10(exp 4) Hz range where experiments can begin; (2) rebuilt beam-chopping electronics to account for finite travel time of ions from source to scattering center; (3) developed new type of fast-risetime, high-voltage circuitry for beam chopping; (4) redesigned electron gun lens system to minimize beam scalloping in the solenoidal magnetic field; (5) generated a beam of O(+) ions at 5.0 KeV of suitable current for scattering measurements; (6) interfaced our PSD computer with the computer automated measurement and control (CAMAC) histogramming memory; and (7) carried out joint NATO research with Belfast Group (Queen's University) on their electron-ion apparatus. We succeeded, by careful gun design and low background pressure, in reducing background electron and ion counts in our PSD to the level where one should be able to detect excitation signal in about 500 sec of data accumulation. The goal of this work is to measure absolute experimental collision strengths and electron-ion scattering phenomena in ions which have significant bearing on the behavior of the solar plasma. The preponderance of collision strengths available are theoretical values of very uncertain accuracy, and with practically no comparisons to experimental data. Using the electron energy loss method, pioneered by us at JPL, one can excite both optically allowed and forbidden transitions in ions, as demonstrated in our previous measurements. A merged-beam apparatus is currently being tested to carry out absolute measurements, in elastic integral cross sections, and near threshold measurements to detect resonance structures. These measurements will be compared with theoretical calculations where available. Immediate goals are: (1) merge electron and ion beams, paying careful attention to the deflection of ion beam by merging and demerging trochoidal plates and to effects of beam shear on the scattered electrons; (2) detect inelastically scattered electrons from beams of O(+) and S(+); and (3) apply appropriate dead-time corrections by collecting all backgrounds and signal plus backgrounds in separate memories.

W90-70358 **188-44-01**
Goddard Space Flight Center, Greenbelt, MD.
RESEARCH COMPUTING FACILITY AND CATALOGING FOR INFRARED RESEARCH
N. W. Boggess 301-286-6989

The scientific objectives of this program are to enhance the ability to interpret observations and continue updating catalogs of infrared observations for the benefit of the astronomical community. This program will maximize scientists' ability to interpret observations and provide information for efficient observing programs. Tools and techniques which will facilitate and improve data reduction, analysis, and understanding of astrophysical data are being developed. The cataloging effort is made available to the scientific community at large, and the computing facilities are made available to visiting scientists.

W90-70359 **188-44-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NUCLEAR ENRICHMENT OF THE INTERSTELLAR MEDIUM
P. G. Wannier 818-354-3347

In the past 12 months, progress was made on molecular outflows in late-type stars, on nuclear abundances in the region of the Galactic Center and on the properties of the cloud boundary layers of molecular clouds. A set of 4.6 micron spectra near 12 stars was analyzed and new data obtained on another 14 stars.

Nuclear abundance data in the galactic center show that the region is not merely enriched by a thorough processing through stars, but that the stars of the galactic center region are themselves unusual in the nucleosynthetic products which they expel. Lastly, the boundary layers of galactic molecular clouds have been analyzed, demonstrating the existence of heating processes not only in the molecular material, but extending into the atomic gas. Studying late-type stars with a Fourier transform spectrometer, mounted on the 4-m Mayall telescope of the NOAO, we obtained high-resolution (0.010 wave numbers) spectra of the fundamental vibration-rotation band of CO. Not only do these demonstrate the cooling of the expanding material as it accelerates, but series of sharp features indicate episodic changes in the expulsion velocity. With additional sub-millimeter wave observations of the SiO molecule, we have used high-excitation lines to trace the current acceleration of expelled material. FY-90 plans are to continue work in the areas mentioned above. The recent stellar data will be analyzed and a paper written about current results. The cloud edge project will be advanced by obtaining J = 3-2 CO data as well as Infrared Astronomical Satellite (IRAS) maps and star-count data to probe the properties of the dust. New submillimeter wave water observations will probe the ionization properties of molecular clouds. In addition we are starting to perform physical/chemical modelling of the boundary regions.

W90-70360 **188-44-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERSTELLAR MICROWAVE SPECTROSCOPY/OBSERVATIONS
T. B. H. Kuiper 818-354-5623

Observations of the 12 GHz transition of methanol and the corresponding 15 GHz transition of C-13 methanol, made with the 70-m DSN antenna near Canberra, have been accepted for publication. Observations of the O-18 species of methanol were made with the Canberra 70-m antenna and prepared for publication. Patrol observations of a selected set of sources were conducted with the Goldstone Venus 26-m antenna to monitor the variability of ionized helium-3 emission at 8.7 GHz. Observations of the 15 GHz formaldehyde transition and the corresponding C-13 transition were made with the Canberra 70-m. Observations were made to determine the efficiency and beam size of the Goldstone 70-m antenna at 22 and 32 GHz. We carried out observations of the 12.179 GHz transition and the corresponding transition of (13)CH3OH at 14.78 GHz. At some positions in the Galactic Center, we found a somewhat higher C-12/C-13 ratio than is indicated by other molecules, which suggests that some detailed excitation analysis may be required (Kuiper et al. 1989). The (13)CH3OH results encouraged us to observe the CH3(18)OH transition at 11.6 GHz. Again, we found a ratio of (12)CH3OH/CH3(18)OH which was larger than expected (Gardner et al. 1989). The K-band (18 to 25 GHz) equipment used for interstellar observations will be re-installed at DSS-43 early in FY-89. Highest priority will be assigned to re-calibration of the antenna at K-band after the installation of a new subreflector and primary reflector panel adjustment. High angular resolution observations of ammonia in southern molecular clouds will be resumed. Observations of methanol at 12 and 15 GHz and formaldehyde at 14 and 15 GHz will also be continued at DSS-43. Observations of helium-3 will continue at DSS-13.

W90-70361 **188-44-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VLBI HIGH RESOLUTION STUDIES OF ACTIVE GALACTIC NUCLEI
R. A. Preston 818-354-6895

The technique of Very Long Baseline Interferometry (VLBI) observations of extragalactic radio sources is an important technology at JPL, supporting both spacecraft navigation and geodetic measurements. In addition, JPL and NASA are presently studying possible involvement in future astrophysical VLBI observatories in space. This task supports VLBI and associated Very Large Array (VLA) observations and analysis for astrophysical purposes. This task works in a symbiotic manner with other JPL VLBI activities, providing them useful data on radio source characteristics and enabling a high productivity of astrophysical research for a small budget. In addition, this task emphasizes the radio astronomical use of the DSN. During the last 16 months, this task has produced 28 published or accepted papers on: (1) VLBI and VLA imaging of quasar and galactic cores; (2) the first VLBI mapping of Southern Hemisphere sources; (3) VLBI astrometry and associated optical identification work; (4) interferometric mapping techniques; and (5) analysis of VLBI observations with an orbiting telescope. The Southern Hemisphere VLBI Array, anchored by the DSN site at Tidbinbilla, Australia, was operated successfully for the first time with seven radio telescopes (including the newly added sites at Culgoora and Perth). This array has significantly improved U-V coverage and sensitivity over the previous version, and should produce good quality maps. The data received from the Culgoora site represent the first scientific use of the new Australia Telescope, a radio imaging array similar to the VLA. A broad range of VLBI and VLA observations of quasar and galactic nuclei will continue. The improvement of the Southern Hemisphere array will also continue.

W90-70362 **188-44-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TIDBINBILLA INTERFEROMETER
S. Gulkis 818-354-5708

During FY-89, we continued the Tidbinbilla interferometer measurement program, and the analysis and the optical identification tasks. We focused our analysis on a sample drawn from the RA range 22 hours to 07 hours, declination zone -30 to -35 degrees. We searched for radio emission from Supernova 1987A at X- and S-band. Measurements using the newly upgraded 70 m antenna were continued and the software was updated to reflect new calibration data. Further tests of the X-band interferometer were carried out. Optical and infrared identifications of radio sources are an important data base for spacecraft such as the Space Telescope. This is the only program that provides such identifications in the Southern Hemisphere. It utilizes the unique facilities of the NASA-DSN tracking station at Tidbinbilla, Australia. Accurate radio positions of 137 extragalactic radio sources contained in the -30 to -35 degree zone of the 2.7 GHz Parkes survey were measured and analyzed. Optical identifications are suggested for 42 of the sources and the optical positions of these were measured. During FY-90, we plan to continue our measurement program of the Parkes radio sources, and to continue our analysis of those sources already observed. Our plan is to push the survey to more southerly declinations. We plan to continue our search for radio emission from Supernova 1987A at S- and X-band.

W90-70363 **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 of specific objects within it. This is achieved by making and analyzing observations at wavelengths from 1 micron to 1 mm and at a wide range of spectral resolving powers, and by conducting theoretical research along with the observations. Since atmospheric opacity and emissivity prohibit or severely limit ground-based observations at certain wavelengths, high altitude platforms such as the Kuiper Airborne Observatory, balloons, or satellites must be used. High sensitivity composite bolometers are being developed in the far infrared to make 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. Tools and techniques which will

facilitate and improve data reduction, analysis, and understanding of astrophysical data are being developed.

W90-70364 **188-44-24**
Ames Research Center, Moffett Field, CA.
THE DEVELOPMENT OF A MID-INFRARED SPECTROMETER FOR THE INFRARED TELESCOPE IN SPACE
T. L. Roellig 415-694-6426

The objective of this RTOP is to develop and construct a Mid-Infrared Spectrometer (MIRS) for the Infrared Telescope in Space (IRTS). The IRTS is a Japanese telescope that will be launched by a Japanese expendable launch vehicle in 1994. The MIRS is a joint development project between NASA and the University of Tokyo. The spectrometer will have a wavelength coverage ranging from 4.2 to 11.3 microns and will be designed for astronomical studies of diffuse infrared sources. The approach of this RTOP is to divide the technical development between NASA Ames and the University of Tokyo. The instrument will be assembled at Ames, tested, and then installed in the Japanese spacecraft. The data will be shared equally between NASA Ames and the University of Tokyo for a proprietary period before release to the general astronomical community.

W90-70365 **188-44-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NEAR IR IMAGING AT PALOMAR
C. Beichman 818-584-2904

During the past 12 months we have used the Palomar Infrared Camera at the 200-inch telescope on approximately 15 nights, of which approximately 7 were clear. The camera works well and has the following performance characteristics over its wavelength range of operation, 1 to 2.5 microns: quantum efficiency = 40 percent; read noise = 1,500 electrons; full well = 800,000 electrons; and dark current = 500 electrons/sec. We have used the camera to observe regions of star formation, supernova remnants, IRAS galaxies, and quasars in a variety of broad and narrow band filters. A major discovery made with the camera was of emission from Fe II toward three Herbig Haro objects, HH7-11, HH12, and HH34. Prominent Fe II emission is associated with the shocked H2 emission. A series of narrow band line images show that the Fe II emission is located upstream of the H2 emission and suggest a model in which a jet of ionized gas from the exciting star impinges on the ambient molecular cloud. Fe II promises to be a sensitive tracer of low level ionized gas in star formation regions and infrared galaxies. The plan for FY-90 is to upgrade the camera with an improved array as soon as possible. We intend to first upgrade the camera using a larger, lower noise version of the HIRIS chip we are presently using. The new 256x256 array is directly compatible with the electronics we are now using; only a new detector mount is required to incorporate the new device. The noise performance of the new device, 600 electron read noise, will make the camera background limited in the broadband filters. Then, depending on the availability of NASA and Caltech/JPL funds we hope to purchase a NICMOS 2 array from Rockwell. This chip with its 30 electron noise will permit greatly enhanced narrow band imaging.

W90-70366 **188-44-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL INTERSTELLAR CHEMISTRY
M. A. Allen 818-354-3665

One goal of the NASA Astrophysics Program is to characterize the molecular evolution of galactic material from the initial diffuse state to the formation of stars and planets. Our efforts in modeling the chemistry of interstellar molecular clouds help provide the means to understand the process of star formation and help form the basis for planning strategies for future NASA missions, such as the Submillimeter Explorer and Large Deployable Reflector (LDR). Available data on radio emission from CO, H2CO, NH3, HC3N, and HC5N in dark clouds have been compiled for comparison with model calculations. The compiled CO data reveal that for A(v) between 1 mag and 4 mag, the relative abundance of the CO to H2 is found to increase, contrary to commonly held belief. The 6 cm data for H2CO appear to sample the outer envelope of dark clouds, where photochemical reactions dominate its destructions. The column density of NH3 remains constant to within a factor of 2 for observed cloud cores. There is a strong correlation between HC5N and HC3N and between HC5N and C4H for several dark clouds, indicating a common production route, through reactions involving C2H2, for long-chain carbon-bearing species. The increase in abundance for CO over the range in A(v) from 1 mag to 4 mag corresponds to a molecular cloud region in which last year we surmised a decrease in the abundance of C II. The observations reveal details of the transformation of C II into the stable CO, a result previously known only through theoretical modeling. Plans for FY-90 are to: (1) continue to incorporate new data, such as radio observations of OH and CH in the outer regions of dark clouds, into the modeling effort; (2) undertake a theoretical analysis of the increase in CO relative abundance for A(v) less than or equal to 4 mag; (3) study the photochemistry of H2CO; and (4) develop the ability to extract results from the model so that estimates of the emitted line radiation from species of critical importance can be obtained as a function of position across a cloud.

W90-70367 **188-44-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SIMULATIONS OF COMPACT RADIO SOURCES
D. L. Meier 818-354-5062

We are performing an extensive study of the propagation of the unmagnetized and magnetized, supersonic jets in compact radio sources which will be studied by future NASA-ESA or NASA-Japan orbiting, very long base interferometry (VLBI) missions (with K. Lind of NRAO and R. Blandford of Caltech). As such objects also radiate profusely in the X-ray, UV, and millimeter regions of the spectrum, this research also will have an important impact on the analysis of data from HEO, AXAF, EUVE, ST, and LDR. Specifically, during the FY-89 year, we have: (1) completed our initial study of very heavy, overpressure jets and their relation to radio sources without cocoons (with A. Sadun of MIT and Agnes Scott College) and presented our results at a recent AAS meeting; (2) begun a new study of light jets with poloidal magnetic fields and helical magnetic fields (poloidal plus toroidal); (3) completely restructured the numerical grid in our code (for increased accuracy, especially in the boundary conditions), upgraded and tested the new code (version 3.0), and ported the code to UNIX Crays at NASA Ames and to Sun Workstations, the latter for data reduction purposes; (4) began testing the code in the magnetic accretion disk regime, obtained another 130 hours at San Diego Supercomputer Center and 25 hours at NASA Ames, and became actively involved in the acquisition, allocation, and use of a new supercomputer at JPL; and (5) had our paper on light magnetic jets accepted in the Astrophysical Journal. Scientific highlights include the discovery that heavy, overpressure jets can form cocoons and the development of an analytic expression which predicts when a jet will or will not form a cocoon based on its initial density and pressure (this has important consequences for radio sources which do not have observed cocoons but appear to be expanding nonetheless). Our work is being featured in the 1988 San Diego Super Computer Center Annual Report (sent to NSF and to Congress) and on the cover of the May issue of Supercomputing Review. It was also chosen by the director of the Cornell Supercomputer Center to represent San Diego's work in his briefing to a congressional subcommittee on 4 May 1989. Work in FY-90 will include: a paper on heavy, overpressure jets; obtaining significant amounts of time on the new JPL supercomputer and porting the code to it; making significant progress in or complete the study of jets with helical fields; and continuing the study of magnetic accretion disks with poloidal and toroidal fields.

W90-70368 **188-44-53**
Ames Research Center, Moffett Field, CA.
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. The approach of this effort involves theoretical analyses and 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 fundamental problems in the areas of interest. These numerical codes treat multi-dimensional hydrodynamic and magnetohydrodynamic fluid problems, multi-dimensional particle problems, and complex chemistry and radiative transfer situations. This effort makes effective use of the advanced computational facilities at Ames.

W90-70369 **188-44-55**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROPHYSICS SUPPORT
C. Beichman 818-584-2904

The purpose of the Astrophysics Support Fund is to bring outstanding scientists to JPL as visitors to work on NASA missions and data. This year we were able to bring Dr. Pierre Encrenaz of L'Ecole Normale Superieure to JPL to work on Kuiper Airborne Observatory (KAO) data taken in conjunction with Wannier and to work on the Submillimeter Explorer. Funds from this RTOP were combined with the internal JPL funds to pay Dr. Encrenaz's salary and expenses for his 3 month stay in Pasadena. A major highlight of Encrenaz's work at JPL will be the submission to CNES of a Phase A proposal for the Submillimeter Explorer. We anticipate bringing Dr. Encrenaz back to JPL next year to continue the collaboration between CNES and JPL astronomers in this area. Kuiper and Encrenaz will be preparing a number of papers based on their KAO data. The work Encrenaz will be doing at JPL will be incorporated into proposals for the Submillimeter Explorer.

W90-70370 **188-44-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERSTELLAR MICROWAVE SPECTROSCOPY/LAB PROGRAM
R. L. Poynter 818-354-7374

This program measures and catalogs spectral lines in the frequency range below 3000 GHz. The results are for both planning and interpreting observing runs made with either airborne/spaceborne or ground based instrumentation. The new version of the catalog has been expanded from 151 to 181 atomic and molecular species. Approximately 60 magnetic tape and 99 fiche copies of the prior catalog have been requested by the scientific community. A paper has been submitted on the rotation-torsion spectrum of carbodiimide. A paper has been submitted on the microwave spectrum of the radical aluminum oxide. A paper is in preparation on the line frequencies and strengths of water. A paper is in process on the combination of Fourier transform infrared (FTIR) data and laser sideband measurements of cyanamide, with predictions of the spectrum out of 200 cm(exp -1). The magnetic tape form of the catalog has been reformatted to make access of specific atomic or molecular species easier for users. New files have been added for H2D(+) and the isotopic species of water. Work in FY-90 will expand the submillimeter spectral line catalog to include a number of new molecular species and publish the new version of the catalog.

W90-70371 **188-44-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ION-MOLECULE REACTIONS
V. G. Anicich 818-354-2439

Radiative association reactions are projected to be a significant process in the evolution of interstellar gas clouds. In 1980 we published our first reports of a radiative association reaction measured in the laboratory. Over the last nine years this reaction and others that we have reported have exposed some apparent inconsistency in results in various pressure regimes. We believe that in this last year we have solved this difficulty. In generating ions, they are as likely as not to be formed in their ground states. The radiative association type reaction in actuality is very energy sensitive. We were able to observe the change in reactivity of several ions along radiative association channels. This change was modeled satisfactorally as the energy relaxation of the reactant ions, prior to association. By understanding the energetics of the reaction and the population distribution of the ions, the results from the different pressure regimes are then all consistent. We were able to follow the reactive ions in the HC3N(+)/HC3N and the C2H2(+)/C2H2 systems as a function of time. In both these systems radiative association occurs between the secondary ions and the parent neutrals. We found that there was an induction period in the reaction of the secondary ions. This could only be explained as the secondary ions being formed with enough internal energy to block the radiative association reaction. After several non-reactive collisions the secondary ions became reactive and we measured the reaction rate constant which now agrees with other experiments. The initial radiative association reaction that we reported was the reaction between CH3(+) and HCN. We plan to study this reaction in the same detail that the above systems were studied. The accumulation of data in the future will lead to predictions about systems that are difficult to work with in the laboratory, e.g., C(+)/H2.

W90-70372 **188-44-57**
Goddard Space Flight Center, Greenbelt, MD.
LABORATORY ASTROPHYSICS
J. Nuth 301-286-9467

The overall objective of this program is to obtain laboratory measurements of quantities and processes which can lead to a better understanding of astrophysical systems. As part of this general objective, both theoretical analysis and studies were undertaken to model appropriate systems. The objectives of the specific tasks supported under this RTOP are: (1) to obtain high resolution spectra (one part in 10(7)) of isotopically labeled molecules in sufficient detail to construct energy level diagrams of individual vibrational states; (2) to determine the pre-condensation cluster distribution leading to the nucleation of refractory circumstellar particles; (3) to determine the spectra of amorphous grains of various compositions for comparison with interstellar/circumstellar dust; (4) to obtain far infrared spectra of various ices and grains for comparison with astrophysical observations using SIRTF and SOFIA; and (5) to understand the evolution of organic/metallic ice grains as a function of chemical composition and degree of irradiation and warmup. Data required to achieve the above objectives will be obtained using a variety of experimental techniques and equipment. In particular, objective (1) will be accomplished using a combination of tunable diode lasers and Fourier Transform Spectrometers (FTS). Objective (2) will be accomplished a unique dust generator built at GSFC and a combination of annealing/hydration system, Cary-14 UV-visible spectrometer and FTS. Objective (4) requires use of a low-T cryostat and FTS while (5) requires both of these system, plus a 1 MeV proton accelerator.

W90-70373 **188-44-57**
Ames Research Center, Moffett Field, CA.
PROPERTIES OF INTERSTELLAR PAHS
L. J. Allamandola 415-694-6890

The objective of this RTOP is to understand why free molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects. The PAHs are a widespread, previously unrecognized, component of the interstellar medium and play a dramatic role in determining many properties such as energy balance, molecular cloud temperature and chemistry, and carbon dust particle formation. The approach of this RTOP is to increase 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 all data pertaining to this problem are

spectroscopic. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further our understanding of the roles of PAHs in astrophysics. First experiments are underway in the new 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.

W90-70374 **188-46-01**
Marshall Space Flight Center, Huntsville, AL.
CONTROLS, ASTROPHYSICS, AND STRUCTURES EXPERIMENT IN SPACE
John M. Davis 205-544-7600
(170-38-51)

Controls, Astrophysics, and Structures Experiment in Space (CASES) is a joint initiative of MSFC and LaRC for the study of the behavior of large structures in space within the framework of the Controls Structures Interaction Program of OAST. Through the use of a 32 m extendable boom mounted to the STS, CASES will study the pointing, slew and figure control, and the vibration suppression of flexible bodies, while pointing a hard X-ray imaging telescope at both the Sun and a celestial target. A strawman scientific program of observations and analysis has been suggested. This program together with the instrument design, including both optics and detectors, will be reviewed by a ten member Science Working Group (SWG), which was selected by NASA Headquarters in March 1989. This evaluation will be required in early 1990 in order to support the CASES Phase C/D contractor selection. Beyond this the SWG will monitor the development of the CASES facility with particular emphasis on maintaining the integrity of the scientific objectives. The SWG will remain in existence until approximately 1 year prior to launch which is currently scheduled for May 1993. The activities of the SWG will be supported through this RTOP.

W90-70375 **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 astronomy, energetic particles, and cosmological studies. Multisatellite data sets, such as those of Ariel 5, OSO 8, HEAO 1 and HEAO 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. An additional important task is the definition of the manner in which new data will be added to this respository for future work by archival investigators. Strong emphasis is placed on creating the theoretical framework for interpreting the results, using the data to test recent 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.

W90-70376 **188-46-01**
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)
F. C. Witteborn 415-694-5520

The objective of this RTOP is 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. The approach of this RTOP is to model interaction processes which are likely to be important to the spectral evolution such as: pair-production, annihilation, Compton scattering, Bremsstrahlung, Coulomb scattering, and if a magnetic field is present, synchrotron/cyclotron emission.

W90-70377 **188-46-57**
Marshall Space Flight Center, Huntsville, AL.
GAMMA RAY ASTRONOMY
Gerald 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 space-borne 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.

W90-70378 **188-46-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GAMMA-RAY ASTRONOMY
W. A. Mahoney 818-354-6606

The prime objective of this task is the development of instrumentation to measure 0.02 to 10 MeV nuclear gamma radiation from extra-terrestrial objects. The main approach involves the development of position-sensitive detectors to be used with coded aperture masks to obtain high energy and high spatial resolution maps of the cosmos. Current work involves both xenon ionization drift chambers and segmented germanium detectors, with the emphasis expected to shift more toward the germanium detectors during FY-90. Development of an advanced, more finely segmented detector will begin. During FY-89 the work has primarily involved testing the segmented germanium detector and assessing its performance. During the remainder of the year preparations will continue for a collaborative balloon test flight of a second segmented detector currently being built at Lawrence Berkeley Laboratory. Preparations will also continue for assessing the performance of the segmented detector when a Stirling cycle refrigerator is used for cooling. A collaborative effort with the Caltech Campus is under way to design and test a coded aperture mask for use with the segmented germanium detector. During FY-90 a collaborative balloon flight will be conducted from Australia to test the performance of the segmented germanium detector in a near-space environment. Vibration and electromagnetic interference (EMI) tests of its performance will be conducted with a Stirling cycle refrigerator. A coded aperture mask will be designed, built, and tested with the segmented germanium detector.

W90-70379 **188-46-57**
Marshall Space Flight Center, Huntsville, AL.
GAMMA RAY IMAGING TELESCOPE SYSTEM (GRITS)
R. B. Wilson 205-544-7695

This RTOP covers a continuing development program to better determine the secondary gamma-ray background rejection properties and sensitivity of the Gamma Ray Imaging Telescope System (GRITS). This proposed high energy (greater than 200 MeV) gamma-ray detector would make use of an STS-ET (external tank) 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. These ongoing studies would continue during FY-90. Under this RTOP, Monte Carlo simulations of charged particle interactions with the Energetic Gamma Ray Experiment Telescope (EGRET)/GRO have been performed in order to validate the simulation. Having obtained satisfactory results, simulations of the current GRITS concept are now in progress.

W90-70380 **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 being pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low enery 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, and sensitivity, including the study of techniques to build much larger systems. In the range from 0.5 to 40 MeV, it is apparent that substantial sensitivity improvement will require elimination of the ambiguity produced by conventional Compton telescopes in determining the direction of a detected gamma ray. New detector technology and a new approach is therefore required. 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.

W90-70381 **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 the 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.

W90-70382 **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-band width has been our approach in discovering and exploring these phenomena. The power of this approach was well demonstrated. Extending it with improved spectral resolution and broad-band 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, imaging devices, and monitoring instrumentation.

W90-70383 **188-46-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
X-RAY ASTRONOMY CCD
S. A. Collins 818-354-7393

The objectives of this investigation are to develop a charge coupled device (CCD) whose characteristics are optimum for X-ray astronomy (energy response 0.2 to 10 KeV; energy resolution: 150 eV FWHM at 5.9 KeV; and spatial resolution to .25 line pairs/micron); and to develop a CCD-based X-ray astronomy imaging spectrometer for use in a Pennsylvania State University (PSU) sounding rocket payload. During FY-89, CCD's from Ford Aerospace and Lincoln Laboratory were operated in a manner which yielded unprecedented levels of low noise (1.7 e(-) and 3.6 e(-), respectively). Such performance, coupled with excellent charge transfer efficiency, resulted in energy resolution which is limited by the Fano factor, i.e., at the theoretical limits: 80 eV (FWHM) at 1.5 KeV and 153 eV (FWHM) at 5.9 KeV. In addition, techniques were developed which reduced the CCD's vulnerability to ionizing radiation damage and which reduced the rate of dark current generation, enabling operation at higher temperatures (delta t approx. = 50 C) and reducing the risk of condensate contamination. The sounding rocket payload, flown in FY-88, was not flown in FY-89. During FY-90, fabrication and testing will be accomplished of CCD's whose frontside structures have been modified to provide enhanced low-energy response (0.1 to 2 KeV). The modification consists of opening windows in the frontside gates, so that part of each pixel is unobscured by polysilicon and by implanting ions to control the potential within these window regions.

W90-70384 **188-46-59**
Marshall Space Flight Center, Huntsville, AL.
X-RAY ASTRONOMY
M. C. Weisskopf 205-544-7740

The purpose of this program is to conduct research in the field of X-ray astronomy in areas related to the Astrophysics programs of NASA. 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 and infrared 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. Another objective of the program is to design, build, test, and fly imaging proportional counters of advanced design. These instruments will incorporate new techniques developed at Marshall Space Flight Center and will provide a level of performance far superior to conventional instruments. The instruments will have applications in imaging, timing, and spectroscopy. In addition, new methods for detecting X-ray polarization will be developed.

W90-70385 **188-48-52**
Ames Research Center, Moffett Field, CA.
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-694-4164

The objective of this RTOP 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. The approach of this RTOP is to show that the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. The 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.

W90-70386 **188-78-01**
Marshall Space Flight Center, Huntsville, AL.
ADVANCED ASTROPHYSICS SYSTEMS STUDIES
J. R. Dabbs 205-544-0623
(188-46-00; 188-50-00)

The objective of this RTOP is to contribute to the NASA Astrophysics Research Program by conducting advanced systems studies and analyses that will increase the basic understanding of advanced astrophysics systems, advanced optical systems, and observatories. Utilizing the talents of MSFC in-house personnel and laboratory capabilities, specific study activities as described in the tasks of this RTOP will be accomplished.

W90-70387 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL INTERFEROMETRY IN SPACE
S. P. Synnott 818-792-6933

Our strategy is to quantitatively assess the scientific capabilities of several optical interferometer designs and from these studies to identify the technological developments needed to achieve the goal of deploying a high resolution imaging or astrometric instrument in space in the near future. We have initiated a detailed study of the scientific opportunities provided by optical imaging instruments capable of resolutions exceeding that of hypersonic transport (HST) by a factor of ten or fifteen. We are generating both a comprehensive list of all the accessible astrophysical object types, and also detailed analyses of representative objects. The purpose of these efforts is to translate the scientific goals into quantitative requirements on interferometer spacecraft systems. At the same time we have spent considerable effort understanding, with both theoretical and computational approaches, the overall signal-to-noise capabilities of various system designs, beam combining approaches and spectroscopic techniques. Optical beam combining approaches in both the image and pupil planes have been analyzed. Optical designs capturing both dim science objects and brighter reference objects have been investigated and found to be promising. A large number of detectors are being catalogued and quantitatively assessed. Software to simulate the front end optical fringe forming and detection process, and the image reconstruction process, is being developed, using the radio very long baseline interferometry (VLBI) packages where appropriate. Detailed analyses to understand how to fit a spectroscopic instrument to the interferometer output have been initiated. Analyses of the vibrational characteristics and the overall attitude behavior of reasonable spacecraft models are being conducted because of the impact on overall instrument signal-to-noise ratio (SNR). All of these developments are being coordinated from an overall systems point of view. Minimization of complexity is a highly desirable system level goal to minimize cost. All of the efforts described above will continue. The science object models will serve as benchmarks against which to compare the performance of various interferometer designs, considering their basic capabilities and likely error sources. Optical, detector, spectroscopic and imaging studies will continue with the goal of finding optimal matches to achieve certain scientific studies. A range of interferometer types from simple, limited capability Explorer-class missions up to great observatory-class missions can be analyzed quantitatively with the approach described here. Spacecraft systems studies on deployment options and hardware, and on vibration and attitude capabilities will continue to allow identification of needed technology developments in those areas.

W90-70388 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RELATIVITY ADVANCED TECHNOLOGY STUDIES/DEVELOPMENT
R. W. Hellings 818-354-3192

The purpose of this research is to identify and develop the technology required for missions in experimental gravitation. This task will be advised by the Scientific Coordinating Committee for Experimental Gravitation (SCCEG). This body will assess the scientific value of various program options, consider the technical feasibility of mission concepts, identify crucial technology items, and evaluate the approaches used to solve technical problems. In the current fiscal year, this committee has met twice and has arrived at a program involving spaceborne clock technology development at SAO, disturbance reduction technology for laser interferometer missions at JILA, spacecraft microwave ranging accuracy improvement at JPL, spacecraft-spacecraft Doppler tracking stability assessment for microwave interferometer missions at UC Santa Barbara, and full-aperture metrology technology development for optical interferometry at JPL. Proceedings of the Annapolis workshop in June 1989, were published. This document outlines most of the relevant scientific objectives, mission possibilities, and technology opportunities. The next meeting of the SCCEG will be held in September 1989 to assess the progress of the studies supported and to make plans for the next fiscal year. Details of the planned accomplishments will be found in the minutes of that meeting.

W90-70389 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STUDY OF TECHNOLOGY FOR A SUBMILLIMETER ASTROPHYSICS MISSION
W. J. Wilson 818-354-5699

The objective is to support pre-Phase A studies for the Submillimeter Explorer project in preparation for a future space astrophysics mission. This will include a definition of the science goals, the instrument and spacecraft characteristics and requirements, and studies of submillimeter local oscillator sources. In FY-89 this task was supported by the NASA RTOP and the JPL Director's Discretionary Fund. This included studies of the antenna and optics, the heterodyne radiometers, and system studies of project strategy and cost. In October and March, meetings were held with our French collaborators on the technology readiness and project configuration. Development of the heterodyne radiometers is critical for this project and three specific research areas were studied: (1) the development of a 500 GHz solid state local oscillator (LO) source at the Millitech Corp; (2) studies for low capacitance varactor diodes for submillimeter frequency multipliers at the Univ. of Virginia; and (3) studies of a harmonic SIS mixer at JPL to reduce the LO frequency by one-half and make the LO problem easier. In FY-90 it is planned to continue the pre-Phase A studies required for the Submillimeter Explorer astrophysics space project. The main goal will be to define the Submillimeter Explorer project to fit within the constraints of technology readiness and available resources and to further coordinate the joint French and U.S. work. Studies will continue on submillimeter LO sources for the heterodyne radiometers since this is the most critical component at this time.

W90-70390 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMILLIMETER OBSERVING SYSTEMS DEVELOPMENT FOR ASTRONOMY APPLICATIONS
M. J. Mahoney 818-354-5584

The strategy of the observing systems portion of the restructured Large Deployable Reflector (LDR) RTOP includes a continuation of the JPL team of scientists and engineers who have supported the LDR studies since Asilomar 1. The design team will continue conceptual development in areas considered to be of highest priority by the Asilomar 3 technology and science panels, with particular emphasis on the needs of possible LDR precursor mission options and related technology programs. Work was completed on the tolerance requirements for a segmented aperture reflector; this will provide the basis for optical requirements of the Civil Space Technology Initiative (CSTI)/Precision Segmented Reflector (PSR) program and ultimately LDR. The thermal impact of new orbit options was also analyzed; this work verified the benefit of a high orbit on the thermal background of a submillimeter telescope. In April, work began to develop an

end-to-end structural, thermal, and disturbance model for LDR. This work will be completed early in FY-90. Areas to be addressed in the next fiscal year are driven strongly by the instrument needs of an LDR precursor mission. This will include the characterization of SIS junctions and the development of a cryostat design tool. In addition, the augmentation work begun in April will be completed. This will result in an end-to-end LDR model analyses, which can be used for mission trade studies.

W90-70391 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROPHYSICS TECHNOLOGY PROGRAM
J. S. Cutts 818-354-4120

The purpose of the investigation is to develop a long range technology plan for the NASA Astrophysics Division. The scope of the investigation will include all techniques, including imaging, spectroscopy, photometry and interferometry applied across the electromagnetic spectrum from gamma to radio wavelengths. The task will involve close coordination with The National Academy of Sciences Committee recently chartered to update the nation's long-range research program in astronomy and astrophysics and with the Advisory Committees (Shapiro's and Branch's Committees) established by the NASA Astrophysics Division. This task will lead to a detailed technology plan by the spring of 1990 with a final published plan by the end of 1990.

W90-70392 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL INTERFEROMETRY WITH SEPARATE SPACECRAFT
D. L. Jones 818-354-7774

An optical interferometer in space offers many advantages over ground-based systems, including much longer integration times (and thus higher sensitivity), longer baselines, and the ability to extend frequency coverage into the ultraviolet and far-infrared regions. It is widely thought that the easiest approach to a space-based interferometer is to mount multiple apertures on a single, rigid structure. However, it is very likely that a complex system of laser metrology and optical path control will be needed to provide the required level of phase stability. Consequently it may be possible to remove the mechanical structure without a significant increase in over-all complexity. We plan to investigate concepts for optical interferometers using multiple spacecraft to determine their feasibility. A system with separate spacecraft would allow multi-kilometer baseline lengths, providing micro-arcsecond angular resolution.

W90-70393 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LOW FREQUENCY RADIO INTERFEROMETRY FROM THE MOON
D. L. Jones 818-354-7774

The lunar surface provides a nearly ideal location for an array of simple antennas to image the entire sky at very low radio frequencies (a few MHz) with high angular resolution. Such observations are impossible from the earth or from low earth orbit. A low frequency radio array could be one of the first, unique scientific uses of a lunar base. The prospect of observing the universe at frequencies below the ionosphere plasma frequency is exciting, as it opens a new spectral window several octaves wide for astronomical research. We need to determine the technical feasibility of a lunar-based low frequency array, and compare it to previously studied arrays of satellites in high earth orbit. Previous funding from the JPL Director's Discretionary Fund has allowed various technical aspects of low frequency very long baseline interferometry (VLBI) with an array of small satellites to be studied. These studies have identified solutions to several problems, but the problem of interference from the earth remains a serious concern. Some of the specific areas to be investigated are concepts for simple, light-weight, self-deploying antennas, the use of fiber optical links between the antennas, estimation of the size and weight of the correlator (which may be located at the lunar base), investigation of the limits on coherent integration time imposed by the solar wind, and the severity of radio interference from the earth.

W90-70394 **188-78-44**
Ames Research Center, Moffett Field, CA.
STUDY OF LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY
D. J. Hollenbach 415-694-4164

The objective of this RTOP is 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 for the Large Deployable Reflector (LDR). The 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. The approach of this RTOP is to undertake critical analysis of various concepts by studying each one individually. 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, and chopping and flat fielding. The primary objective is to determine which optical design is best suited for sensitive IR photometric observations, and the requirements on the nodding and chopping rates to achieve desired levels of sensitivity. A 2-D Fast Fourier Transform solution to the wave optics of an LDR model is numerically solved on a CRAY 2 computer.

W90-70395 **188-78-44**
Ames Research Center, Moffett Field, CA.
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) continue mission design studies to understand SIRTF in high earth orbit using ELV's and to prepare RFP for Phase B studies of the telescope facility and the selected instruments.

W90-70396 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMILLIMETER MISSION OPTIONS STUDY
William B. Gray 818-354-1090

The objective of the Submillimeter Mission Options Study is to define submillimeter mission options corresponding to an Explorer class mission, a moderate class mission and a major class mission. Conceptual designs, costs, and science returns from each class mission will be presented for evaluation by Code EZ. Based on the science, technology, and design work performed in previous years, and continuing under the accompanying RTOP, conceptual designs will be prepared for the moderate and major classes of missions described above and the results of the separate Submillimeter Explorer study incorporated. As a part of the study, mission and operations concepts will be presented, including low and high earth orbit options for each mission class. Estimated costs up to launch plus 30 days will be presented for each option. Finally, the effect of possible international cooperation in each mission option will be considered.

W90-70397 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORBITING VERY LONG BASELINE INTERFEROMETRY (OVLBI)
J. F. Jordan 818-354-7790

The objective of this RTOP is to develop scientific goals and advantages of space Very Long Baseline Interferometry (VLBI) and develop the plans for appropriate participation for the U.S. in international space VLBI missions. The Japanese have selected a space VLBI mission, the VLBI Space Observatory Program (VSOP) as the next scientific mission in ISAS. The Japanese have expressed a strong interest in U.S. participation in their mission. The purpose of this RTOP is to assess the scientific potential of these missions, and, particularly, the advantages to the U.S. radio science community of NASA participation. The RTOP will support U.S. role definition and support to the Astrophysics Division in the negotiations with the Japanese and/or Soviets for U.S. participation in their respective missions. The NSF Astronomy Survey Committee in 1980 specified that a space VLBI mission ranked as a high national scientific priority.

W90-70398 **188-78-46**
Marshall Space Flight Center, Huntsville, AL.
ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
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 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, HEAO-2. An ongoing technology mirror assembly program has already demonstrated the achievability of nearly all the AXAF optic goals. This RTOP activity will place emphasis on completion of design definition phases of the AXAF program to assure a sound basis for Phase 2 approval in FY-92.

W90-70399 **188-78-60**
Ames Research Center, Moffett Field, CA.
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 1990's as the successor to the Kuiper Airborne Observatory (KAO). The SOFIA features a 2.5-meter 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, the consoles and electronics subsystem, and the Federal Republic of Germany (FRG) telescope assembly; and (4) to acquire 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.

Planetary Astronomy

W90-70400 **196-41-00**
Lyndon B. Johnson Space Center, Houston, TX.
COMPOSITIONAL STUDIES OF PRIMITIVE ASTEROIDS
F. Vilas 713-483-5056

The objective of this proposal is to study the composition of primitive (C, P, D, F) asteroids through the study of their spectral properties, and to apply the acquired knowledge to the understanding of the origin and history of these asteroids and their possible link to other solar system objects. The approach will include: (1) obtaining new narrowband Charge Coupled Device (CCD) reflectance spectra of main-belt and outer-belt primitive asteroids and satellites in the 0.35 to 1.0 micron spectral range; and (2) studying these spectra for fine absorption features which have been correlated with iron oxide features seen in terrestrial phyllosilicates and carbonaceous chrondrites to understand the history of aqueous alteration within the solar system.

W90-70401 **196-41-03**
Lyndon B. Johnson Space Center, Houston, TX.
ATMOSPHERIC AND SURFACE COMPOSITION OF MERCURY AND THE MOON
A. E. Potter 713-483-5061

One 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 second objective is to detect the presence (or absence) of ice in permanently shadowed regions of the Moon near the lunar poles. These regions are dimly illuminated by light scattered from surrounding highland. The near infrared spectrum of these regions will be measured at times when lunar libration makes them visible to ground-based telescopes.

W90-70402 **196-41-30**
Marshall Space Flight Center, Huntsville, AL.
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 microns to 30 microns. These observations will be performed from ground-based infrared observatories. A second infrared imaging system, containing an InSb detector array spanning the wavelength region 1 micron to 5 microns, is now under development. Beginning in the second half of FY-90, observations with this instrument will importantly complement those obtained with the 20-bolometer array. A third system, a linear array of 10 bolometers to operate at 0.4 K, will be used at 8 to 30 microns and will have very high sensitivity and high spatial resolution (0.8 arc sec). This array will be ready for operation in the second half of FY-90 and will be used to detect comets at very large heliocentric distances.

W90-70403 **196-41-50**
Goddard Space Flight Center, Greenbelt, MD.
GROUND-BASED INFRARED ASTRONOMY
Donald E. Jennings 301-286-7701
(188-44-57; 154-50-80)

The scientific objectives 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 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 searched for, near 8 microns. These observations were made at 0.01 1/cm 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 x 50 element array. This instrument will yield another order-of-magnitude improvement in sensitivity.

W90-70404 **196-41-51**
Goddard Space Flight Center, Greenbelt, MD.
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 and other instruments 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. Imaging observations will be made at 2 cm wavelength of those asteroids with sufficient regular diameter to be well resolved by the VLA. The expected results are: radio emission spectra spanning the widest range in wavelength for 1 Ceres, 2 Pallas, 4 Vesta, and 10 Hygeia; two cm observations of selected smaller asteroids; interpretation of the spectra by inversion techniques; 1.3 mm and 3.3 mm observations of a selected set of major asteroids Microwave Image; and 1.3 mm rotation curves for 1 Ceres and 4 Vesta.

W90-70405 **196-41-52**
Goddard Space Flight Center, Greenbelt, MD.
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 wind. Research is most effective when in situ solar wind and IMF data from spacecraft are available to compare with the imagery. 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 comets since 1973, including recent comets IRAS-Araki-Alcock, Giacobini-Zinner, Halley, and Bradfield has been carried out. Analysis of some of the imagery have provided 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, and the pressure balance conditions across the tail. The sudden growth of a plasma tail in comet IRAS-Araki-Alcock appears to have been caused by a very large X-class solar flare and the resultant sudden pulse of photoionization in the coma. Most spectacular, Disconnection Events (DEs) of the plasma tail were discovered in JOCR images of comet Kohoutek and have been convincingly shown to result from sector boundary crossings and magnetic reconnection.

W90-70406 **196-41-54**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED INFRARED ASTRONOMY AND SPECTROSCOPIC PLANETARY DETECTION
M. J. Mumma 301-286-6994
(154-50-80; 157-05-50)

The objectives of this RTOP are twofold: Task 01 studies the molecular constituents of solar system objects (e.g., planetary atmospheres and comets) through observations of their IR line spectra. High spectral and 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 microns), and to utilize grating and Fourier transform instrumentation in the near infrared (lambda less than 8 microns). Observations are conducted from ground-based observatories and from the Kuiper Airborne Observatory (KAO). Task 02 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 stars. The objective of this task is to validate such an approach by measuring the velocity stability of integrated sunlight with Fourier transform and heterodyne spectrometers. 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.

W90-70407 **196-41-67**
Ames Research Center, Moffett Field, CA.
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 approach is 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

W90-70408 **199-02-31**
Lyndon B. Johnson Space Center, Houston, TX.
TECHNOLOGY WATCH FOR CREW HEALTH CARE SYSTEM (CHECS)
J. Boyce 713-483-0452

Current Space Station Freedom 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 has been developing the requirements and systems for a modular inflight medical system known as Crew Health Care System (CHeCS). CHeCS is comprised of the following components: Health Maintenance Facility (HMF), Environmental Health System (EHS), and Exercise Countermeasure Facility (ECF). The unique challenge

of providing health care coverage for Space Station Freedom requires the development of low weight, low volume, highly automated health care based as much as possible on terrestrial tenants and equipment.

W90-70409 **199-02-31**
Lyndon B. Johnson Space Center, Houston, TX.
LONGITUDINAL STUDIES (MEDICAL OPERATIONS LONGITUDINAL STUDIES)
Edward C. Moseley 713-483-7102

The objective of the research in this area 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 covered 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 consists of 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.

W90-70410 **199-04-11**
Lyndon B. Johnson Space Center, Houston, TX.
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.

W90-70411 **199-04-11**
Lyndon B. Johnson Space Center, Houston, TX.
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 early manned space operations. While currently available information is sufficient for 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 a 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.

W90-70412 **199-04-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIATION AND ENVIRONMENTAL HEALTH
G. A. Nelson 818-354-4401

The objectives of this RTOP are to delineate the genetic and developmental effects of high Linear Energy Transfer (LET) radiation (similar to that found in space as cosmic ray of High-Charge Energy (HCE) particles) and to understand how cellular repair systems process radiation induced damage. The simple animal C. elegans was used as a model system in radiobiology studies conducted at JPL, the Lawrence Berkeley Laboratory BEVALAC accelerator (source for accelerated ions), and the Argonne National Laboratory (neutron source). Cell survival and differentiation were investigated using the development of a 4-cell gonad primordium into a complex functioning adult structure. Autosomal visible and lethal mutations and chromosome aberrations leading to formation of nucleoplasmic bridges and duplications of X chromosome segments are being analyzed to understand particle-induced genetic lesions. The kinetics of production of these various lesions were investigated as functions of particle parameters such as Linear Energy Transfer (LET). Relative biological effectiveness (RBE) and action cross sections versus LET were described for several lesions. The structures of ion-induced lethal mutants are under investigation by genetic crosses, deletion mapping and, in the case of unc-22 mutants, by DNA hybridization techniques. Modification of mutagenesis and chromosome aberration kinetics is being tested using radiation sensitive rad mutant strains which report the activities of different DNA repair pathways. The nature of DNA repair systems will be further investigated by the isolation of new radiation sensitive mutants using transposon Tc1 mutagenesis to permit future molecular characterization of repair system gene products. The effects of track structure and free radicals are being probed by variation of ion velocity and the partial pressure of oxygen.

W90-70413 **199-06-11**
Lyndon B. Johnson Space Center, Houston, TX.
BIOBEHAVIORAL RESEARCH
Patricia A. Santy 713-483-7111
(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 was 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 the 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; and (3) to develop strategies to facilitate psychological adaptation to the space environment.

W90-70414 **199-06-11**
Lyndon B. Johnson Space Center, Houston, TX.
BEHAVIOR AND PERFORMANCE
Barbara J. Woolford 713-483-3701

The objectives of this RTOP are: to quantify human performance capabilities and limitations and move toward quantification of man-machine engineering data, both on the ground and in flight; to continue to pursue state-of-the-art technology and to advance that technology for the purpose of creating more effective and efficient tools for measuring or analyzing human performance; to collect, organize, and make accessible data on space human factors so that innovative steps may be taken toward creating better interfaces in future vehicles. The approach is: 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 actual flight conditions; to continue those efforts currently defined that lead toward definitive design requirements for use as inputs to an automated crew station design system; and, to pursue feasibility studies of promising new crew interface items and methods.

W90-70415 **199-06-12**
Ames Research Center, Moffett Field, CA.
BEHAVIOR, PERFORMANCE AND HUMAN FACTORS
Bruce W. Webbon 415-694-6646
(591-36-32)

The research objectives of this RTOP incorporate substantive, methodological, and applied concerns, specifically: (1) understanding individual, group, and environmental/task factors that affect group performance and well-being in an aerospace context; (2) developing better methodological techniques for studying the processes mediating effects of such factors on crew outcomes; and (3) interpreting and applying research results to specific problems (current or anticipated) in aerospace operations. Areas of particular interest are selection and training of crews, guidelines for organizing teams and the distribution of workload (both human and automated functions), techniques for monitoring performance and providing countermeasures to stressful and high-risk conditions, and methodological tools for evaluating the effects of training, standards, procedures, and intervention techniques. Past group productivity research has lacked in generalizability because of its uncritical use of laboratory settings. Methods of analysis have also failed to provide meaningful and valid results to the operational community. The research represented in this RTOP takes an integrated approach to the validity problem; that is, it uses a variety of paradigms and research environments to converge on well-rounded and operationally sound solutions to complex problems.

W90-70416 **199-08-11**
Lyndon B. Johnson Space Center, Houston, TX.
GENERAL BIOMEDICAL: CENTER AND HEADQUARTERS SUPPORT
Jerry L. Homick 713-483-7108

Long duration manned space flight requires investigations which will certify the health of crew during extended operations in microgravity and their safe return to Earth after mission activities in space. The support for broad-based programs which provide enabling capabilities (including personnel) for the implementation of these investigations is included in this RTOP. The RTOP encompasses Center-wide management of four programs which are essential to the life sciences activities of the Johnson Space Center and the objectives of Office of Space Science and Applications (OSSA). Extended Duration Orbiter (EDO) development is intended to support mission safety by developing recommendations and countermeasures for optimizing crew performance and proficiency for nominal and contingency entry, landing and egress. This includes the consideration of the occupational and habitability factors of extended duration missions.

W90-70417 **199-14-11**
Lyndon B. Johnson Space Center, Houston, TX.
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: provocative techniques such as lower body negative pressure and exercise testing, bed rest studies as analogs to weightlessness, noninvasive and invasive cardiovascular monitoring, and pharmacologic interventions, all in an effort to accomplish the goals set forth above. Inflight measurements will be performed as required to collect data which cannot be obtained on the ground, and to verify countermeasure protocols. Benefit will be greater access to the space flight environment for more diverse segments of the popular under a greater variety of conditions. Cardiovascular deconditioning, manifest as inappropriate heart rate and blood pressure response to orthostatic testing, was documented during and/or after all manned flights.

W90-70418 **199-14-12**
Ames Research Center, Moffett Field, CA.
CARDIOPULMONARY PHYSIOLOGY
A. R. 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: define underlying mechanisms; determine whether specific cardiovascular risks occur with short- and long-term microgravity exposure; develop and test appropriate models and countermeasures to prevent or to treat cardiopulmonary deconditioning; and 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) determining effects of exercise training on deconditioning; (2) exposing of humans to horizontal and head-down bed rest and water immersion to study mechanisms of deconditioning; and (3) testing procedures, devices and drugs 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. The results will also provide access to flight of a broader segment of the population, and will use weightlessness to expand the understanding of cardiopulmonary/fluid-electrolyte function and autonomic nervous system control of the cardiopulmonary system.

W90-70419 **199-16-11**
Lyndon B. Johnson Space Center, Houston, TX.
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 and can appear upon reentry and landing. 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 zero-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: (1) to conduct research which leads to a better understanding of the underlying mechanisms of SAS and fully develop effective and operationally useful preflight and inflight countermeasures, and (2) to develop techniques to minimize reentry phenomena and to facilitate readaptation to one-g. The approach will be to conduct an interrelated series of operationally oriented ground-based and space flight studies designed to address some 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.

W90-70420 **199-16-12**
Ames Research Center, Moffett Field, CA.
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 microgravity 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) space 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 microgravity on the CNS can be determined. The general approach to understanding these components and mechanisms involves identifying in both ground and flight investigations the functional and 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.

W90-70421 **199-16-22**
Ames Research Center, Moffett Field, CA.
NEUROSCIENCE (INFORMATION PROCESSING)
M. D. Ross 415-694-5757
(199-28-22; 199-26-22)

The long-term goals of this research are: (1) to understand information processing in animal linear bioaccelerometers, on Earth and in space, through experimental research and computer-assisted reconstruction and modeling; and (2) to learn whether gravity interacts with the genome to produce the endorgan organization present in the adult. The RTOP represents a coordinated approach to research on mechanisms underlying transduction, on the morphological organization of the macular neural network and its evolution, on physiological characteristics of vestibular nerve responses and on the development of the gravity-sensing endorgans. The findings of the past few years are now being utilized in modeling efforts that rely greatly on use of computer technologies. In particular, the finding that mammalian maculas are organized for distributed, parallel processing of linear acceleratory information is capitalized upon. The approaches to achieving the goals listed above place heavy emphasis on experimental study in combination with computer-assisted reconstruction and modeling. Mathematical approaches are becoming increasingly important. Models generated can be used to predict changes likely to occur in space and will be tested at a future date through highly focused, rigorous experiments in the space environment. Studies of both developing and adult animals in space will be required to satisfactorily answer questions concerning the role of gravity in shaping the mature system and to increase our understanding of macular (and neural) adaptation to altered gravity.

W90-70422 **199-18-11**
Lyndon B. Johnson Space Center, Houston, TX.
REGULATORY PHYSIOLOGY
Nitza M. Cintron 713-483-7165
(199-14-11; 199-26-11)

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.

W90-70423 **199-18-12**
Ames Research Center, Moffett Field, CA.
REGULATORY PHYSIOLOGY (BIOMEDICAL)
J. Vernikos-Danellis 415-694-3736
(199-14-12; 199-06-12; 199-16-12)

The objectives of this program are to determine the integrative mechanisms regulating long-term physiological adaptation to space. The consequences to 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. Specific activities will include: (1) the development of countermeasures for the impaired thermoregulation in deconditioned subjects during exercise; (2) the study of the relationship of stress-induced immune dysfunction to health risk; and (3) the effect of altered/adapted physiological baseline of the body's stress responding systems on the ability of crews to respond to physical, emotional and operational stresses and to perform. Results will improve flight and Extra Vehicular Activity (EVA) safety and improve the development of safer and more effective countermeasures.

W90-70424 **199-26-11**
Lyndon B. Johnson Space Center, Houston, TX.
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 bones' apparent demineralization and dissolution are the central questions addressed by the present research program. It is intended 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 inter-relationship 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. Clinical human and animal models will be used to define the mechanisms underlying bone and muscle mass regulation and loss during space flight and their recovery after 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.

W90-70425 **199-26-11**
Lyndon B. Johnson Space Center, Houston, TX.
EXERCISE COUNTERMEASURE RESEARCH (MUSCULOSKELETAL II)
Bernard A. Harris, Jr. 713-483-4895
(199-11-11)

The Exercise Countermeasure Project 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. The Exercise Countermeasure Facility will be developed through ongoing ground-based, and KC-135 and Shuttle flight research. The emphasis of this project is to conduct the physiologic research for examining muscle, cardiovascular, and bone deconditioning secondary to adaptation and study the effects of exercise on this adaptation. Three exercise modalities have been selected for continued development. These are the treadmill, combination recumbent ergometer/rower, and resistive exerciser. In addition to the hardware development, extensive basic and operational research objectives must be met. A characterization of exercise response must be compared with ground-based and in-flight studies. Initially, the definition of the effects of microgravity on the musculoskeletal, cardiovascular, and neuromuscular systems will be developed. This will be accomplished through studies addressing muscle strength pre- and post-flight; examining the neuromuscular characteristics with Electromyogram (EMG); defining the biomechanical parameters for exercise and work in space; and determining the muscle histological effects of microgravity.

W90-70426 **199-26-12**
Ames Research Center, Moffett Field, CA.
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 and in ground simulation models 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 documented in the Skylab experiments: 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.

W90-70427 **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 muscle volume from magnetic resonance images (MRI). This technique is designed for use in bedrest studies or for pre- and post-flight monitoring of muscle atrophy. In parallel, an ultrasound technique for measurement of muscle volume is under investigation and initial tests strongly suggest the feasibility of this approach. The method utilizes a magnetic spatial locator device to track the position of the ultrasound imaging probe as it is applied to various positions along the length of a muscle. Computer image processing methods are used to reconstruct the volume of the entire muscle. The two approaches to muscle volume assessment complement one another in the sense that MRI has the potential for very accurate volume measurements and can be used to validate the ultrasound technique. The ultrasound method in turn, has the potential for in-flight use.

W90-70428 **199-26-22**
Ames Research Center, Moffett Field, CA.
MUSCULOSKELETAL (SUPPORT STRUCTURES AND BIOMINERALIZATION)
E. M. Holton 415-694-5471
(199-28-22; 199-18-22; 199-16-22)

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 is focused on mechanisms of bone response to unloading. Mineralizing bone cell cultures and invertebrate mineralization mechanisms are also being studied. Spaceflight experiments on Cosmos, Shuttle or Lifesat missions will be used as possible to obtain data for comparison with ground-based research.

W90-70429 **199-28-21**
Lyndon B. Johnson Space Center, Houston, TX.
CELL AND DEVELOPMENT BIOLOGY
Clarence F. Sams 713-483-7160
(199-21-51)

Space flight was 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 improve the understanding of the biological changes

observed in microgravity. Several tasks 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 organisms.

W90-70430 **199-30-00**
Ames Research Center, Moffett Field, CA.
REGIONAL AND GLOBAL MODELING OF NITROGEN AND CARBON GAS FLUXES
P. D. Sebesta 415-694-5232
(199-30-62; 199-30-72)

The objective of the RTOP is to develop models designed to predict the influence of climate change and land use change on biogeochemical cycling and flux of trace carbon and nitrogen species. The approach of this RTOP is to collaborate with on-going studies of climate and disturbance effects on gas flux in order to develop simulation models that incorporate controlling variables and that can be driven by coarse scale parameters available in current global data bases.

W90-70431 **199-30-32**
Ames Research Center, Moffett Field, CA.
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.

W90-70432 **199-30-62**
Ames Research Center, Moffett Field, CA.
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 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 regional and global budgets. 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 scales.

W90-70433 **199-30-72**
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
D. L. Peterson 415-694-5899
(677-21-00)

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. The approach is to test 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 1990. 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 support a workshop in the third year.

W90-70434 **199-30-76**
Langley Research Center, Hampton, VA.
TERRESTRIAL BIOLOGY AND ATMOSPHERE BIOSPHERE INTERACTIONS
S. Levine 804-865-4345

The objectives of this RTOP are to quantify particulate and gaseous emissions from biomass burning and to quantify pre- and post-burn biogenic gas emissions.

W90-70435 **199-30-86**
Langley Research Center, Hampton, VA.
TERRESTRIAL BIOLOGY AND ATMOSPHERE BIOSPHERE INTERACTIONS
D. S. Bartlett 804-865-4345

This study will develop remote sensing techniques to evaluate the role of plants in wetland gas fluxes through photosynthetic fixation of atmospheric CO2. During FY-90 studies will be conducted in tropical grasslands of the south Florida Everglades and sub-arctic tundra and bogs of eastern Canada.

W90-70436 **199-30-99**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL INVENTORY MONITORING
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 of this RTOP are: (1) the understanding of large-scale vegetation response and its relationship to atmospheric CO2 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 to 1990.

W90-70437 **199-30-99**
Goddard Inst. for Space Studies, New York, NY.
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 to 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.

199-30-99

W90-70438
Goddard Inst. for Space Studies, New York, NY.
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 input 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.

199-52-11

W90-70439
Lyndon B. Johnson Space Center, Houston, TX.
CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES
Everett K. Gibson, Jr. 713-483-6224

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 inter-planetary 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.

199-52-12

W90-70440
Ames Research Center, Moffett Field, CA.
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-694-5909
(199-52-22; 199-52-32; 199-50-42)

The objective of this RTOP 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 following lines of inquiry are pursued: (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; and (4) determine exobiology requirements for new telescope capabilities and recommend observation priorities.

199-52-14

W90-70441
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 sup +, 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.

199-52-22

W90-70442
Ames Research Center, Moffett Field, CA.
PREBIOTIC EVOLUTION
S. Chang 415-694-5733
(199-52-12; 199-52-32)

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 on 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.

199-52-26

W90-70443
Langley Research Center, Hampton, VA.
PHOTOCHEMISTRY/GEOCHEMISTRY OF THE EARLY EARTH
Joel S. Levine 804-864-5692

Objectives are to develop a better understanding of the geochemical 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.

W90-70444 **199-52-32**
Ames Research Center, Moffett Field, CA.
THE EARLY EVOLUTION OF LIFE
L. I. Hochstein 415-694-5938
(199-52-22; 199-52-47)

The objective of this RTOP is to understand the nature and evolution of primitive organisms and to relate such evolution to those forces which shaped the evolution of the planet. The approach of the RTOP will be to explore the mechanisms, processes, and environments associated with the early evolution of life on Earth in order to understand the possible existence of life elsewhere in the Universe. Two repositories of evolutionary information are examined: the molecular record in living organisms 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, acidophilic thermophiles) 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 analyses 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.

W90-70445 **199-52-52**
Ames Research Center, Moffett Field, CA.
SOLAR SYSTEM EXPLORATION
G. C. Carle 415-694-5765
(199-52-12; 199-52-22; 107-20-08)

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. The approach will be to define and develop improved methods, instrumentation, and experiments 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.

W90-70446 **199-52-72**
Ames Research Center, Moffett Field, CA.
THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE MICROWAVE OBSERVING PROJECT (SETI MOP)
D. H. Brocker 415-694-3650

The objectives of the Search for Extraterrestrial Intelligence (SETI) Microwave Observing Project (MOP) are to build, deploy, and operate the equipment to conduct a search for microwave transmissions of intelligent extraterrestrial origin. Specific objectives for FY-90 are: (1) complete phase B system definition studies and begin phase C/D preparation for the Targeted Search Operational System (TSOS) and Sky Survey Multichannel Spectrum Analyzer (MCSA); (2) complete the initial software and hardware configuration of the Targeted Search Prototype (TSP); (3) design and fabricate the Sky Survey Prototype (SSP); (4) continue surveying the Radio Frequency Interference (RFI) environment; and (5) continue observatory selection and preparation, and select the SETI dedicated site. The approach includes implementing the SETI Project to the standards of a NASA flight project. Results of the Phase B studies will be evaluated to determine the optimal TSOS and Sky Survey MCSA design. Commercially available computer systems will be evaluated, purchased, and implemented as TSP signal detectors. The TSP system software will be completed in-house at ARC. The Sky Survey Prototype (SSP) will be developed in-house at JPL. RFI surveys will be conducted at Arecibo, NRAO, and other potential SETI sites. Cost/benefit trade-off studies will be made of Algonquin Radio Observatory and Ohio State University Radio Observatory for choosing the dedicated site.

W90-70447 **199-55-12**
Ames Research Center, Moffett Field, CA.
ADVANCED PROGRAMS IN BIOLOGICAL SYSTEMS RESEARCH
R. D. MacElroy 415-694-5573
(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 ground work for advanced missions; and (2) to 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.

W90-70448 **199-59-12**
Ames Research Center, Moffett Field, CA.
SCIENCE DEFINITION FOR PLANETARY PROTECTION
G. C. Carle 415-694-5765
(199-52-52; 107-20-68; 199-52-22)

The objective of this RTOP is to provide specific information that will enable the Agency's Planetary Protection Officer to define requirements for specific future solar system exploration missions, e.g., Mars Penetrator Mission and Mars Rover Sample Return Mission. Through basic and applied research a science data base will be developed applicable to missions that will contact the Martian surface. The approach of the RTOP is to determine the limits of microbial viability and growth determined for a variety of environmental conditions applicable to Mars. For example, it has been suggested that the surface of Mars is self-sterilizing because of its apparent oxidative capacity. By altering the redox potential of a variety of soils and determining the growth and viability of microorganisms inhabiting these soils under differing redox potentials, the relationship between soil redox potential (and oxidative capacity) will be determined. Would a terrestrial microbe survive in the Martian soil beneath the surface oxidizing layer. This and other questions will be explored by examining microbial growth, survival, and physiology in deep sub-surface environments as a function of water potential, carbon use and metabolism, and thermal stability of microbes in halite crystals.

W90-70449 **199-61-11**
Lyndon B. Johnson Space Center, Houston, TX.
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 environments 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 FY-90 approach is to: (1) continue dissolution laboratory experiments on simulated lunar glass; (2) continue plant growth experiments with prepared soils in the plant growth chamber; (3) develop a fairly representative lunar mineral and lunar glass simulant for continued investigation and to allow comparability of results among researchers; and (4) continue research on the formation, characterization, and utility of zeolitic minerals which can be synthesized from lunar regolith under mild hydrothermal conditions.

W90-70450 **199-61-12**
Ames Research Center, Moffett Field, CA.
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 ensure 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.

W90-70451 **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

A sound engineering and scientific approach will be carried out to build an operational bioreactor system for testing on STS missions. Prior to the actual flight experiment, a ground based experimental analysis of Microbial Bioreactor Systems (MBS) is required. The approach to meeting the needs of biological processing in microgravity requires development of a production model reactor and a reactor that can provide a means to examine microgravity effects on cellular processes. Development of a production model reactor has already progressed to the point where a ground based model has been built and tested. This phase separated membrane bioreactor (PSMB) Mark I model has been undergoing testing to provide ground based data. Upon further analysis the model is expected to provide the data necessary to build a Mark II type model which would better approximate an actual piece of flight hardware. A reactor which can be used to examine microgravity effects has not yet been completely designed although several possible models have been proposed. Reactor design(s) must be able to permit examination of: (1) Cell biology effects such as DNA replication, cell division, and morphology; (2) Intracellular metabolic effects; and (3) Microbial ecological effects such as the intercellular metabolic dependencies found in heterogeneous microbial populations. In terms of design possibilities, the specific question drives the design. Designs for generic reactor configurations which are adaptable for special growth requirements for examining microgravity effects will be examined. Designs for ground based models to test concepts will be followed by the construction and testing of such models. This basic engineering data will permit trade-offs analyses.

W90-70452 **199-61-31**
Lyndon B. Johnson Space Center, Houston, TX.
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. The FY-90 approach is to: (1) complete 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; (4) perform initial conceptual design of a ground-based, crew-rated CELSS Test Bed; (5) develop research and technology base in food production/processing and waste management; and (6) stage a workshop on CELSS simulation.

W90-70453 **199-70-22**
Ames Research Center, Moffett Field, CA.
DATA ANALYSIS - EXOBIOLOGY PLANETARY DATA STUDIES AND LIFE SCIENCE DATA SYSTEM DEVELOPMENT
G. C. Carle 415-694-5765
(199-52-52; 107-20-08)

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 databases and conducting studies of existing databases which are supportive of Life Sciences science goals in previous and future flight experiments. The approach of this RTOP, in the area of exobiology, will be to conduct computational studies of existing databases from Mariner 6 and 7 and Viking to obtain information about the geochemical nature of the Martian surface. In the area of biomedicine, a database will be prepared from previous bedrest studies to allow the integration and cross referencing of this data to make it available for a broader cross section of Life Science investigators.

W90-70454 **199-70-32**
Ames Research Center, Moffett Field, CA.
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 by future Life Sciences flight experiments in the laboratory, in earth orbit, and in solar system exploration. In the area of exobiological solar system exploration experiments, 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.

W90-70455 **199-80-22**
Ames Research Center, Moffett Field, CA.
HUMAN INSTRUMENTATION
A. R. Hargens 415-694-5746

The objective of this RTOP is to develop instrumentation for noninvasive or minimally invasive measurement of human physiological parameters during spaceflight. The approach of this RTOP is to include ground-based studies. Experiments will aid development of the instrumentation and provide an important testbed to verify the accuracy and reliability of the new noninvasive instrument by comparison to standard invasive procedures.

Astrophysics Mission Operations and Data Analysis

W90-70456 **399-18-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIPPARCOS VLBI
R. A. Preston 818-354-6895

The European Space Agency (ESA) satellite HIPPARCOS will determine the positions, proper motions, and trigonometric parallaxes of 10(5) optical stars with unprecedented accuracy. It is proposed to tie the HIPPARCOS observations to the JPL 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 the understanding of the physics of the magnetosphere of these stars where the radio emission is thought to originate. Such astrophysical study will be not only an interesting by-product of our 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.

W90-70457 **399-20-01**
Goddard Space Flight Center, Greenbelt, MD.
SPACE ASTROPHYSICS DATA SYSTEM - DAVID GATEWAY SOFTWARE
Barry E. Jacobs 301-286-5661

The purpose of this project is the development of software that supports the addition of new catalogs into the Astrophysics Data System. The technical objectives are: (1) the development, installation, and testing of conversion functions (RA, DEC) that will help astrophysicists to more uniformly access the additional on-line astronomical catalogs; (2) the development, installation, and testing of macros that will facilitate the astrophysicists utilization of the additional on-line astronomical catalogs; and (3) the development, installation, and testing of browsing software that will enable astrophysicists to practice their queries on the additional (and existing) on-line astronomical catalogs.

W90-70458 **399-30-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IPAC ASTROPHYSICS DATA SYSTEM (ADS) SUPPORT
J. Good 818-584-2939

The Infrared Processing and Analysis Center (IPAC) provides support for the Astrophysics Data System (ADS) project which involves systems integration; in particular, user interface definition and implementation and the incorporation of distributed operating systems services into the ADS framework. Overall systems integration oversight will be provided by IPAC personnel. IPAC personnel will also define the user interface methodology and oversee the actual development of this software by contractors.

W90-70459 **399-30-00**
Ames Research Center, Moffett Field, CA.
ASTROPHYSICS DATA SYSTEM
M. G. Burton 415-694-3118
(450-17-00)

The objective of this RTOP is to further evaluate the use of telescience techniques as applied to the Space Infrared Telescope Facility. This is a continuation and extension of the objectives of the Telescience Testbed Pilot Program. The approach of this RTOP will be: (1) to have the science instrument teams along with the Project Office and others contracted to the project to evaluate existing telescience techniques, software and hardware systems that have been developed to determine their applicability for our project requirements; and (2) to develop those areas which are new and unique. Approaches such as the new scheduler at the Space Telescope Science Institute, proposal preparation software used with Roentgen Satellite (ROSAT), operations software and data base management systems will be considered for applicability to Telescience.

W90-70460 **399-30-01**
Goddard Space Flight Center, Greenbelt, MD.
SPACE ASTROPHYSICS DATA SYSTEM - ASTROPHYSICS MASTER DIRECTORY (AMD) IUE DATA CENTER NODE, AND GENERALIZED CATALOG INTERFACE
Don West 301-286-6901

The purpose of this project is to make the International Ultraviolet Explorer (IUE) Data Center a participating node to the NASA Astrophysics Master Directory System (AMDS). The technical objective of this effort is to construct and maintain an IUE interface with the AMDS. This IUE interface will provide to all astronomers a direct interface to one of the most actively accessed data bases available. During this fiscal year the IUE Observatory will continue its participation in and support of the AMD working group. The maintenance of the IUE Data Center Node in AMD system will be continued. Support will be provided to all users in the astronomical community who access IUE archive information and data via the AMD system. CRONUS and KDS will be installed as soon as they are available. An on-line version of the IUE scientific publications bibliography is being planned as part of IUE observation information files.

Space Physics Theory

W90-70461 **431-03-00**
Goddard Space Flight Center, Greenbelt, MD.
MHD TURBULENCE, RADIATION PROCESSES AND ACCELERATION
M. 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; and (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, D. A. Roberts, and A. Vinas of the Laboratory for Extraterrestrial Physics in collaboration with W. H. Matthaeus of the Bartol Research Institute and S. Ghosh, a Postdoctoral Associate supported by the Goddard Visiting Scientist Program. Particle

acceleration in solar flares will be studied by R. Ramaty and J. Miller (a Postdoctoral Associate) of the Laboratory for High Energy Astrophysics and C. Werntz (Catholic University) 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, and D. C. Ellison of the North Carolina State University.

W90-70462 **431-04-00**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL MAGNETOSPHERES STUDIES
D. H. Fairfield 301-286-7472

The objective of this project is to collect, organize, and analyze data from a number of NASA and non-NASA spacecraft in the inner magnetosphere that are not all readily available to magnetospheric researchers. The analysis will focus on substorms and related processes and exploit the unique multipoint aspects of the data. The data set will ultimately be made available to the general magnetospheric community in a convenient format for further studies. Continuation of this project into the International Solar Terrestrial Physics (ISTP) era can provide important baseline information on substorm onset times and locations in support of the more distant ISTP spacecraft.

W90-70463 **431-06-00**
Goddard Space Flight Center, Greenbelt, MD.
SUPER-COMPUTER SUPPORT
M. 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. In particular, this RTOP supports much of the super-computing needs of research supported by NASA's Solar Terrestrial Theory Program. The funding support of $125K will provide a total allocation of approximately 1400 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.

Space Physics SR&T

W90-70464 **432-20-00**
Marshall Space Flight Center, Huntsville, AL.
MODELS OF CORE PLASMA PROCESSES
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 magnetospheric; (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.

W90-70465 **432-20-00**
Goddard Space Flight Center, Greenbelt, MD.
SOLAR WIND-MAGNETOSPHERE COUPLING, MAGNETIC FIELD MODELING AND MAGNETOTAIL DYNAMICS
Daniel N. Baker 301-286-8112

This research effort consists of three separate parts. The first task involves the study of solar wind coupling to the magnetosphere/ionosphere system. The objectives are to understand better the quiet magnetosphere configuration, to study substorm dynamics and dissipation processes, to investigate particle acceleration processes, and to study atmospheric coupling via relativistic electron precipitation. The research approaches involve a combination of data analysis, statistical studies, and numerical modeling. The second task supports data analysis and modeling of the magnetotail structure and dynamics. The approach is to assemble the Interplanetary Monitoring Platform (IMP-8) and International Sun-Earth Explorers (ISEE-3) observations during 1982 to 1983 into a single data base and to then perform correlative analyses of the data for a variety of solar wind conditions. The third task is to perform global modeling of the Earth's magnetosphere using empirical techniques. The approach was to develop accurate representations of the major magnetospheric current systems (magnetopause, ring current, magnetotail, and Birkeland currents) and to then compare the resultant models with new magnetic data from satellites.

W90-70466 **432-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAGNETOSPHERIC COUPLING
R. Goldstein 818-354-0241

This RTOP comprises three separate tasks. Solar and interplanetary-magnetospheric causes and coupling into the magnetosphere of intense magnetic storms (-360 nT less than or equal to D st less than or equal to -250 nT) are investigated. Interplanetary field and particle data will be examined to look for possible correlations with the observed storms. MHD disturbances in the magnetotail and the rapid changes of magnetic field in the near-earth magnetotail are analyzed. Data from Spacecraft Charging at High Altitude (SCATHA) and International Sun-Earth Explorers (ISEE-3) to look for wave-particle interactions are used. Driver gas magnetic fields and high speed solar wind streams in ISEE-3 field and particle data are examined. Stream-stream interactions, magnetic clouds, and correlations with magnetic storms are observed.

W90-70467 **432-36-00**
Goddard Space Flight Center, Greenbelt, MD.
COMET/SOLAR-WIND INTERACTION USING GROUND-BASED IMAGERY AND SPACECRAFT MEASUREMENTS
Malcolm B. Niedner, Jr. 301-286-5821

This RTOP examines the large-scale interaction between bright comets and the solar wind/interplanetary magnetic field (IMF) using remote imagery of (primarily) Halley's Comet and various sets of spacecraft measurements, including those of the Halley Armada spacecraft. The primary goals are to identify the physical mechanisms for plasma-tail disconnection events (DEs), tail rays, and helical waves by establishing solar-wind and IMF conditions at the comet when these features were occurring, as well as by modelling; and to place the snapshot plasma/field encounter data returned by the Halley Armada in the larger temporal context provided by large-scale imagery taken frequently during the interval spanning the first and last encounters (VEGA-1 on March 6 and Giotto on March 14, 1986). There are other (less primary) goals for this program which have been identified in the proposal which was submitted in response to NASA Research Announcement 88-OSSA-2; some of them are listed in Section (14). The Halley imaging data were taken under the auspices of the Large-Scale Phenomena (L-SP) Discipline of the International Halley Watch. Because M. B. Niedner, the P. I. of this RTOP, also serves as the Discipline Specialist for the L-SP Discipline, the imaging data which this study requires reside at NASA/GSFC. The data themselves are digital images created from original glass plates taken by the L-SP Network Observers, using GSFC/Code 684's two

Perkin-Elmer microdensitometers. The computer hardware and software tools exist to analyze these digital images within Code 684. Several of the Halley Armada PIs for the plasma and field experiments have already contributed data to the RTOP PI, and there is every indication that this will continue on the near term. One of the VEGA PIs, K. Schwingenschuh, is an occasional collaborator with M. Niedner. Moreover, many useful data exist for non-encounter spacecraft such as Pioneer Venus Orbiter, International Monitoring Platform (IMP-8), and International Cometary Explorer (ICE) (which encountered comet G-Z), and most of these data are already in hand.

W90-70468 **432-36-00**
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 Interplanetary Monitoring Platform (IMP), Dynamic Explorer (DE) and International Sun-Earth Explorers (ISEE) 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 National Space Science Data Center (NSSDC) to acquire data processed at experimenters' facilities and utilized for analyses, and to transfer these diverse data sets to a common format on optical disks; and (4) production of the data sets which were 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 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.

W90-70469 **432-36-00**
Goddard Space Flight Center, Greenbelt, MD.
SUPPORT FOR SOLAR-TERRESTRIAL COORDINATED DATA ANALYSIS WORKSHOPS (CDAWS)
Robert E. McGuire 301-286-7794

As the 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 solar-terrestrial Coordinated Data Analysis Workshops (CDAWs) aimed at: (1) the immediate exploitation of existing opportunities for fruitful collaborative research workshops, specifically the data collection that has resulted from the Polar Regions Outer Magnetosphere International Study (PROMIS) observational campaign; and (2) 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. The primary focus of this RTOP in FY-90 will be ongoing support, including some few key system and database enhancements, for the CDAW-9 (CDAW-PROMIS) workshop series now underway.

W90-70470 **432-36-00**
Goddard Space Flight Center, Greenbelt, MD.
IACG COORDINATED SCIENCE PLANNING AND DATA ANALYSIS
Robert E. McGuire 301-286-7794

International and NASA space physics programs of the 1990s (e.g., IACG Solar-Terrestrial Science and GGS/ISTP programs) will emphasize multi-spacecraft/multi-agency studies to probe (in situ) the three-dimensional structure and dynamics of large-scale plasma systems like the earth's magnetosphere and the solar-terrestrial system. Maximizing the scientific return in these programs (and similar programs in other disciplines) will place an unprecedented emphasis on coordinated science planning and data analysis. Under this RTOP, a multi-year program is proposed to build on the existing National Space Science Data Center (NSSDC)/WDC-A Satellite Situation Center (SSC) and Coordinated Data Analysis Workshop (CDAW) programs to meet immediate IACG science planning and analysis requirements and evolve toward GGS/ISTP support. Elements proposed under this RTOP include: (1) SSC support for approved IACG magnetospheric models (e.g., Tsyganenko and IGRF88); (2) a (dual) port of the current SSC software from its current (outdated) hardware/software environment to modern (e.g., VMS and UNIX) hardware and operating systems; (3) enhancements to SSC software capabilities for IACG support; (4) a distributed SSC capability (software and database access), to be given to ISAS, ESA and Intercosmos (if possible); and (5) extensions to the existing CDAW concept and capabilities using the upcoming Polar Regions Outer Magnetospheric International Study (PROMIS) workshop and data (e.g., from Viking, DE, CCE, IMP, ISEE) as a testbed for IACG coordinated data analysis.

W90-70471 **432-36-57**
Goddard Space Flight Center, Greenbelt, MD.
PARTICLE ACCELERATOR FACILITY: MAINTENANCE AND OPERATION OF A CALIBRATION FACILITY FOR MAGNETOSPHERIC AND SOLAR-TERRESTRIAL EXPERIMENTS
Steve K. Brown 301-286-5795

The GSFC Parts Branch operates a nuclear particle calibration facility consisting of a MeV Van de Graaff and a 250 KeV electrostatic accelerator. The facility provides particle energies from 50 eV to 1.6 MeV, and protons via reactions to approximately 20 MeV. Particle species available range from electrons to Xe131, with fluxes from approximately 1 particle/cm(2) sec. to approximately 10(9) particle/cm(2) sec. Bremstralen and X-ray lines can also be produced. It has been a unique facility in the world in this low-energy region. Some of its abilities are now duplicated up to 350 KeV by an accelerator at MPI Lindau. For several years, most work in this facility was in support of magnetospheric and solar-terrestrial programs, although some X-ray work was done for Broad-Band X-Ray Telescope (BBXRT) and material work for Cosmic Background Explorer (COBE). Over the past 5 years, machine time was split fairly evenly between calibration and testing systems, and sounding rocket payloads. Machine usage in the previous 12 months has remained about 85 percent of available working days. The machines were operated for 189 days out of 223 during the last year, excluding maintenance and engineering for incoming instruments.

W90-70472 **432-48-00**
Goddard Space Flight Center, Greenbelt, MD.
ATMOSPHERE-IONOSPHERE-MAGNETOSPHERE INTERACTIONS
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, to identify and understand the physical and chemical processes operating in these regimes, emphasizing how they interact. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the study of long-term phenomena, comparison 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 National Space Science Data Center. The essential data to be used in this investigation include electron densities and temperatures, ion and neutral compsition, neutral winds, ion temperatures and drifts, electric fields, magnetic fields, electromagnetic radiation and energetic particles of magnetospheric and ionospheric origin. These data are used to determine the various interrelated chemical, compositional, dynamical and energetic states of the ionosphere, exosphere, thermosphere and mesosphere and the transport and deposition of mass, momentum and energy in and between these physical regions. These basic properties and processes are then used to analyze specific geophysical phenomena such as: atmospheric escape, electric field induced ion drifts in the ionosphere, chemistry and dynamics of mid and high latitude troughs, auroral substorms, ionospheric storms, Joule heating, PCA events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamic processes, equatorial bubble formation and SAR Arcs.

W90-70473 432-48-00
Marshall Space Flight Center, Huntsville, AL.
EXPERIMENTAL AND THEORETICAL STUDIES OF NATURAL AND INDUCED AURORAS AND AIRGLOW
M. R. Torr 205-544-7591

The purpose of this RTOP is to conduct studies to advance our knowledge of the physics of auroras and airglow, and to extend our 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. Our approach is to use a well-developed interhemispheric model to study the principal thermospheric emissions on a global scale. In addition, an ab initio auroral model will be superimposed on the global emission model, thus permitting separation of auroral from photochemical effects, conjugate from local effects and local from transport effects.

W90-70474 432-48-00
Marshall Space Flight Center, Huntsville, AL.
MAGNETOSPHERIC ROLE OF IONOSPHERIC PLASMA
T. E. Moore 205-544-7633
(432-20-00)

We propose to investigate the role played by ionospheric plasma in the dynamics of the magnetosphere. By this, we mean the influence of the transport and circulation of ionospheric plasma on the dynamical processes of the magnetosphere. A special focus of this study will be the interactions between cool plasma emanating from the ionosphere and the hotter plasma populations found at higher altitudes. This study will build on earlier work based upon basic tools: (1) a semikinetic model of ionospheric plasma, and (2) a particle trajectory tracing model of the motions of superthermal ionospheric particles within plausible three-dimensional models of the magnetospheric fields. These modeling tools are highly complementary and will be employed in the following fashion. First, the semikinetic model will be elaborated to include both upper and lower boundary plasmas of arbitrary characteristics. By varying the character of the boundary plasmas, the effect on the outflow, or equilibrium of the boundary plasmas will be determined. This calculation will have direct application to all ionospheric outflow regions, and to observations of plasma contact surfaces in the plasmapause region. Second, the three-dimensional trajectory code will be fitted with improved models of the magnetospheric magnetic and electric fields, adequate for tracing trajectories into the distant magnetotail. Further, it will be modified so as to construct full particle distribution functions at selected points in space, and to track particles in the time varying fields of the active magnetosphere. Particle trajectories and bulk flow parameters will be derived for self-consistent MHD solutions of the time varying magnetotail, and the effects of varying ionospheric outflow bulk parameters on the magnetotail stress balance will be examined.

W90-70475 432-90-00
Marshall Space Flight Center, Huntsville, AL.
PLASMA INTERACTIONS MONITORING SYSTEM (PIMS) DEFINITION STUDY
W. T. Roberts 205-544-0621

The objective of this RTOP is to contribute to the NASA Space Physics Research Program by conducting advanced systems studies and analyses that will increase the basic understanding of the Plasma Interactions Monitoring System (PIMS) to supply environmental data to Space Station users. A study, begun in 1988, has helped define the measurements required, the instruments needed to make these measurements, and the desired placement on Space Station Freedom. In addition, the International Partners have expressed considerable interest in PIMS and may contribute significantly to the development of the PIMS. PIMS units will be placed at several strategic locations on the Space Station Freedom to provide the data necessary to monitor and study the dynamic processes involved in the environment. This task will utilize in-house resources to study specific accommodation issues for integrating PIMS to the Space Station.

W90-70476 432-90-00
Marshall Space Flight Center, Huntsville, AL.
ADVANCED SPACE PHYSICS SYSTEMS STUDIES
J. R. Dabbs 205-544-0623

The objective of this RTOP is to contribute to the NASA Space Physics Research Program by conducting advanced systems studies and analyses that will increase the basic understanding of advanced space physics systems, advanced optical systems, and observatories. Utilizing the talents of MSFC in-house personnel and laboratory capabilities, specific study activities, as described in the tasks of this RTOP will be accomplished.

Space Physics ATD

W90-70477 433-04-00
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS MISSION PLANNING
R. W. Farquhar 301-286-5840

The objectives include development of new trajectory concepts and orbit-control techniques for space physics missions, and utilization of these, and existing, ideas for a variety of orbital studies for the spacecraft of the Solar-Terrestrial Science (STS) Project of the Inter-Agency Consultative Group (IACG). This work will contribute to the main objective for this RTOP, the preparation and publication of a Handbook on orbits, operations, and coordination for all STS spacecraft for IACG's Working Group 3 (WG-3) on Mission Design and Planning. The Goddard Mission Analysis System (GMAS) and other simpler existing orbital design software will be used, and modified, as needed, to calculate new types of trajectories near libration points, and utilizing lunar and Earth-swingby maneuvers. These trajectories, and well-known ones such as periodic halo and double-lunar swingby orbits, will be used for contingency studies, orbit coordination, and extended mission design for the STS spacecraft, and for others in similar orbits. The IACG WG-3 Handbook will portray the STS orbits, showing various options and possibilities for coordinated measurements, and list pertinent spacecraft data. The Handbook will be updated yearly to reflect changes in mission plans.

W90-70478 433-04-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MERCURY ORBITER
C. L. Yen 818-354-4899

The objective of this RTOP is to advance the flight readiness of the Mercury Orbiter Mission concept developed in FY-88 and FY-89. The approach for achieving the objectives will consist of:

(1) applications of the mission concept developed in FY-88 and FY-89 for specific launch years, including backup options, dictated by NASA's program schedule; (2) investigations of issues on navigation, mission operation, and science sequence design; (3) solving various spacecraft design problems identified in the past; and (4) interactions with the science working team and potential international partners.

W90-70479 **433-06-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR PROBE ADVANCED TECHNICAL DEVELOPMENT
J. E. Randolph 818-354-2732

The objectives of this RTOP are: (1) to continue the Science Study Team evaluation of scientific issues as well as mission and system design concepts; (2) to support the concept development team at JPL; (3) to support the management of the studies at JPL; (4) to support subsystem development within and outside JPL; (5) to support the technology development program established under a separate Code R task; and (6) to develop revised program planning options consistent with guidelines from Code ES. The approach will be to accomplish the objectives cited above and continue to work with the Science Study Team to incorporate new science and mission objectives and requirements.

W90-70480 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
ORBITING SOLAR LABORATORY (OSL) PHASE B
R. S. Tatum 301-286-5108

The Orbiting Solar Laboratory (OSL) is a free flying science mission that will enable solar scientists to observe transient and steady state processes acting at and above the solar surface. The OSL science payload consists of the following instruments: the Coordinated Instrument Package (CIP), the High Resolution Telescope and Spectrograph (HRTS), and the XUV/X-Ray Imager (XXI).

Space Physics Sounding Rocket Research

W90-70481 **435-11-00**
Goddard Space Flight Center, Greenbelt, MD.
SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS
R. A. Hoffman 301-286-7386

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, electric fields, and electromagnetic waves in the atmosphere, ionosphere, and near-Earth magnetosphere. Emphasis is placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Sounding rockets provide the only access for in situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (39 to 90 km). 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. The individual programs supported by this RTOP have traditionally involved extensive collaborations with other U.S. and European scientific groups and facilities, and international campaigns.

Solar Terrestrial ATD Advanced Mission Studies

W90-70482 **443-04-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERDISCIPLINARY ATD STUDIES
S. J. Kerridge 818-354-0899

The objectives of this RTOP is to assess options and cost of adding a Tail Probe to an existing design for a spacecraft carrying out cometary exploration and to provide Code ES with ad hoc support on issues related to Space Physics Mission Planning. The approach for achieving the RTOP is to continue Tail Probe studies as in FY-88 to FY-89 and continue support as in FY-89.

Radio Science and Support Studies

W90-70483 **643-10-01**
Lewis Research Center, Cleveland, OH.
SPECTRUM AND ORBIT UTILIZATION STUDIES
J. W. Bagwell 216-433-3502

The objectives of this RTOP are to: 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); 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; 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 technical meetings of the CCIR and CCITT with primary emphasis on the FSS, and secondary emphasis on the BSS, MSS, and the ISDN; and (3) support participation in other national and international groups that set standards for data transmissions. Conduct the described activities within the framework and schedules of the applicable 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.

W90-70484 **643-10-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPAGATION STUDIES AND MEASUREMENTS
F. Davarian 818-354-4820

The objective of the Propagation Studies and Measurements Program is to support NASA's goal to exploit space by characterizing propagation effects on satellite communication links. 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; to

develop prediction models and/or substantiate the existing ones for cases where no experimental data exist; and to provide support to the 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 communication 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 Advanced Communications Technology Satellite (ACTS) Experiment, the Olympus Experiment, the Mobile Satellite Experiment (MSAT-X), the ETS-V Experiment, and other experimental programs. The second activity is performed by analyzing the results of the first relative to other data bases and publishing the results of these findings. Simulation, modeling, and fade countermeasure 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 will continue. The tasks of this RTOP are carried out primarily at universities and government laboratories.

W90-70485 **643-10-04**
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 develop new system concepts and to identify key enabling technologies leading to the growth of spectrum and orbit resource efficient communications satellite system services. The goal is to make these new systems compatible and able to provide interconnectivity with existing space and terrestrial services. The technical objectives of this RTOP for FY-90 are: (1) to support the evolution of integrated aeronautical, maritime and land mobile satellite systems; (2) to assess the state-of-the-art of technologies being employed on U.S. and international communications satellite systems such as the Advanced Communications Technology Satellite (ACTS), ETS VI, Olympus, etc.; (3) to explore new system concepts such as satellite sound broadcasting; and (4) to provide analyses in innovative modulation and coding concepts in support of new satellite systems. This RTOP will provide support for the evolution of an integrated aeronautical, maritime, and land mobile satellite system by addressing the technology, frequency sharing techniques, and system design issues to meet the substantially different requirements among these services. The technology being developed on high frequency communications satellite projects such as ACTS, ETS VI, Olympus, etc., as well as on L-band satellite systems for aeronautical, maritime, and land mobile communications, will be tracked. The main thrust of the technology study will be the identification of the critical technology and cost drivers leading to more efficient frequency/orbit utilization, easier channel access, and low cost user terminals in the areas of low data rate communciations satellites and satellite sound broadcast reception. This RTOP will develop system design concepts for a satellite sound broadcasting service and address issues such as modulation, diversity, and receiving terminal design and cost. This task will form the main thrust of the RTOP in FY-90. Analyses, mainly in modulation and coding, will be provided in support of specific studies such as satellite sound broadcasting, as well as for more general communications satellite applications where innovative techniques may significantly impact system design and reduce cost.

W90-70486 **643-10-05**
Lewis Research Center, Cleveland, OH.
ADVANCED STUDIES
J. W. Bagwell 216-433-3502

The objectives are to: identify and define new applications for communications satellites; assess future telecommunications needs; define preliminary concepts, configurations, requirements and costs of alternative operational systems for new applications; identify the technologies required to enable the implementation of advanced operational communications satellites; formulate preliminary plans for developing the required technologies; and define and develop advocacy for advanced technology development programs and experiments. This work will be carried out through both in-house and contracted studies. The studies will include the technical, economic and institutional/regulatory feasibility of operational systems (for both government and industry).

Communications Data Analysis

W90-70487 **646-10-01**
Lewis Research Center, Cleveland, OH.
APPLICATIONS EXPERIMENTS PROGRAM SUPPORT
J. W. Bagwell 216-433-3502

The objectives of this RTOP are to: (1) coordinate with other Federal agencies and public sector organizations in the development of experimental satellite communications activities for emergency/disaster communication and public service applications; (2) assist users in the transition from the NASA experimental satellites to commercial satellites to commercial satellites where continuity of service can be assured; (3) demonstrate Applications Technology Satellite (ATS) technology and its applications for other governmental agencies and the public service sector; (4) develop new techniques and applicable hardware for use with other appropriate Government-owned satellites; and (5) manage NASA owned space and ground assets. To meet these objectives in the development and transfer of satellite communication technologies, the approach will be to conduct satellite demonstrations and experiments using appropriate satellites and engage in direct interaction with potential and ongoing users of the spacecraft. This interaction will identify user needs requiring the development of new technologies.

W90-70488 **646-76-00**
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL COMMUNICATION TECHNOLOGY DEVELOPMENT
Mike Fitzmaurice 301-286-6610
(650-76-00)

The objective of the RTOP is to develop the critical technologies needed for satellite based optical communication systems. The satellite systems of interest include both deep space planetary probes which need to relay data to earth at moderate data rates (0.1 to 1.0 Mbps), and near earth satellites which must relay data at high rates (100 to 1000 Mbps). Activities which address the deep space configuration will be conducted at the Jet Propulsion Laboratory while activities pertinent to near earth data relay will be conducted at the Goddard Space Flight Center. Specific objectives are: (1) develop diode pumped solid state lasers for the local oscillator and transmitter functions in heterodyne communication systems; (2) evaluate the application of advanced structural composite materials to optical communication systems; (3) develop high power, solid state laser transmitters for direct detection optical communication systems; (4) develop high performance, high data rate, direct detection receivers; and (5) develop components and subsystems in support of the Optical Communication Flight Systems Development and Demonstration.

Advanced Communications Research

W90-70489 **650-60-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MOBILE COMMUNICATION TECHNOLOGY DEVELOPMENT
William Rafferty 818-354-5095
(643-10-01; 643-10-03; 643-10-05)

This on-going technology development program is aimed at the efficient utilization of orbit, spectrum and EIRP for first and future generations of mobile and personal satellite communications systems (MSAT and PASS). MSAT concentrates on five major areas of core technology: (1) Vehicle Antennas: Develop medium gain (-10 dBic) steerable antennas capable of supporting multiple satellite operation; (2) Digital Speech Coders: Develop digital speech coders with commercially acceptable voice quality and low complexity at 4800 bps; (3) Digital Modems: Develop bandwidth and power efficient modulation techniques which can support 4800 bps in a 5 kHz fading channel; (4) Networking: Investigate multiple access and network management protocols which efficiently use the resources of an integrated voice and data mobile satellite network; (5) System Characterization: Characterize the complete mobile satellite channel (environment and equipment) through system analysis, field experiments and modeling. For MSAT, these activities are centered in the L-Band spectrum allocated for Mobile Satellite Systems (MSS). For PASS, the first objective is to develop and validate system concepts, architectures and enabling technologies for an afforable personal communication and information access satellite system to be operational in the first decade of the twenty first century. This system will be an integral part of, and an enhancement to the nation's telecommunications infrastructure providing vital services to the nation. The second objective is to broaden usage of Ka-Band resources by developing technologies and techniques to overcome channel impairments unique to Ka-Band. These activities are accomplished through in-house JPL efforts and a mix of industry and university contracts. A series of on-going MSAT-X field experiments have validated MSS system concepts and operational equipment. The MSAT-X 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. PASS will continue with system studies and trade-offs, selective technology development and experiments.

W90-70490 **650-60-20**
Lewis Research Center, Cleveland, OH.
SPACE COMMUNICATIONS SYSTEMS ANTENNA TECHNOLOGY
J. W. Bagwell 216-433-3502
(650-60-22)

The objective 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 Circuits (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. 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. The emphasis will be on exploiting MMIC device technology for array systems 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.

W90-70491 **650-60-21**
Lewis Research Center, Cleveland, OH.
SATELLITE SWITCHING AND PROCESSING SYSTEMS
J. W. Bagwell 216-433-3502
(650-60-20; 650-60-22; 650-60-23)

The objective of this RTOP is to conduct research and technology development of components and subsystems for advanced communications satellite systems in the area of on-board information switching and processing, modems, codecs, and cost efficient implementation of ground terminal subsystems. Work focuses on a full range of advanced modulation and coding, space based, and ground based technologies and network control/service life management systems. Work under the RTOP is performed through aerospace communications and electronics industry contracts, university grants and in-house technology development. Work includes advanced technology development of proof of concept (POC), demonstration and flight qualifiable models for: (1) bandwidth and power efficient modems, (2) high speed codecs, (3) digital modems, (4) multichannel demodulators, (5) very high data rate modems, (6) information switching processors, (7) autonomous on-board master control, (8) ground terminal controllers and terrestrial interfaces, and (9) Artificial Intelligence (AI) systems, and real time AI.

W90-70492 **650-60-22**
Lewis Research Center, Cleveland, OH.
RF COMPONENTS FOR SATELLITE COMMUNICATIONS SYSTEMS
J. W. Bagwell 216-433-3502
(650-60-23; 650-60-21)

The objective of this RTOP is to perform research and technology development of radio frequency (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 Circuits (MMIC) technology to space communication systems and their related earth terminals. The approach for achieving the objective will consist of developing analysis and synthesis techniques for the above space program components; applying the developed techniques to determine the basic characteristics of components meeting specified requirements; fabricating proof-of-concept components; and testing and evaluating fabricated components.

W90-70493 **650-60-23**
Lewis Research Center, Cleveland, OH.
COMMUNICATIONS LABORATORY FOR TRANSPONDER DEVELOPMENT
J. W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22; 679-00-00)

The first objective of this RTOP is 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. The second objective is to design, develop and test prototype ground terminal systems for use with Advanced Communications Technology Satellite (ACTS) and other advanced communication satellites. The approach will be 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 bursted 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.

W90-70494 **650-76-01**
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL COMMUNICATION SYSTEM DEVELOPMENT
Mike Fitzmaurice 301-286-6610
(646-76-00)

The objective of this RTOP is to develop and demonstrate the systems level technology needed for future GEO-to-GEO optical communications links. Emphasis is placed on small, low mass, low power dissipation terminals which are capable of relaying high rate digital data with low bit error probability. The effort initiated in

Fiscal Year 1989 under this RTOP is a 4-year program to design, fabricate, integrate and test communication terminals configured for cross-link operations. These terminals will be engineering model quality and will be capable of upgrade to flight qualified systems if flight experiment opportunities materialize.

Data Systems

W90-70495 **656-31-01**
Goddard Space Flight Center, Greenbelt, MD.
COMPUTER NETWORKING
J. Patrick Gary 301-286-9539

The general objective of this RTOP is to advance the use of computer networking to enable NASA-sponsored researchers with ready access to needed, but distributed, data and computing resources. The general objective of this RTOP is planned to be met through: (1) continuing research and development in high speed computer networking application through the investigation, testbed evaluation, and semioperational use in a local area network (LAN) of new 100 to 1000 Mbit/second computer networking technology, including both hardware and software; (2) continuing efforts in the development and application of network services and tools to support users in the use of existing heterogeneous computer network technology as deployed operationally by NASA in the NASA Science Internet (NSI), including the TCP/IP-based NASA Science Network (NSN) and the Space Physics and Analysis Network (SPAN), and by NASA and others in other wide area networks (WANs) such as the RSCS-based BITnet, the TCP/IP-based CSnet, DRI, MILnet, National Science Foundation network (NSFnet), and PSCNI, and the X.25-based NPSS and Telnet - all of which are used heavily by NASA-sponsored researchers; and (3) initiating support for transitioning to International Standard Organization (ISO)-sponsored Open System Interconnection (OSI)-based networking through an application and interoperability assessment of emerging OSI-based products.

W90-70496 **656-50-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SYSTEMS NEWSLETTER
S. L. Dueck 818-354-5073

The purpose of the Information Systems Newsletter 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 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 (Astrophysics Data System, Earth Observing System, NASA Climate Data System, Pilot Land Data System, Navigation Ancillary Information Facility, NASA Ocean Data Systems, etc.) and at related workshops, conferences and meetings (NASA Standard Initiator, Visualization, Super-computing, Space Station, etc.). Technical and policy review are provided by JPL's Office of Space Science and Instruments and by NASA Headquarters.

W90-70497 **656-61-01**
Goddard Space Flight Center, Greenbelt, MD.
DATA SYSTEM INTEROPERABILITY
James R. Thieman 301-286-9790

The first objective of this RTOP is to investigate, define, and implement a unified approach to developing and interconnecting data information systems so that the systems are interoperable and researchers may rapidly obtain information about the worldwide diversity of space and earth science data of interest. The second objective is to enable efficient distribution of up-to-date information about data throughout the system by applying metadata standards. In a continuing effort coordinated by the NSSDC, representatives from participating data information systems work together toward implementing interoperability in the following steps: (1) determine, together with a science advisory group, requirements for interoperability; (2) develop a standardized Directory Interchange Format (DIF) for passing information among the data systems for input and update of directory-level information; (3) develop, operate, maintain, and continually improve a NASA Master Directory which has a comprehensive set of space and earth science data set descriptions entered via the DIF; (4) assure the quality, consistency, and completeness of directory-level information by a discipline scientist review process; (5) identify and implement useful interconnections so that a user may search, starting with the directory, for data of interest and choose to be transferred through computer networks to the places where further information is available; (6) assist a user in searches among the data systems by automated transfer of information describing the user's requests and/or performing automated queries of multiple data systems; and (7) 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 including a standardized lexicon of terminology.

W90-70498 **656-61-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA SYSTEM INTEROPERABILITY
T. H. Handley 818-354-7009
(656-80-03)

Nearly a decade of experience with the Code E pilot data systems has taught us that there are many data system functions which are broadly applicable, independent of the science discipline supported by the data system. We have also seen a trend toward decentralization of data system implementation, implying that there will be a need for a great many small, independently developed data systems to support future Code E operations. Thus, there is now a major opportunity to capture the experience of the data systems community in the form of standard data system requirements, architectures, designs, and even portable, reusable code modules. This RTOP proposes an orderly process, which has been proven by unusually successful experience in the intercenter, interagency, and international domains, for systematizing the experience of the data system architectural model, a set of formal interface standards, and a set of portable software modules which, taken together, will greatly facilitate the creation of new data sytems or the addition of important functions to existing data systems. The process proposed will: (1) produce a document which identifies and analyzes the requirements which have been proven by experience to be common across a wide variety of data systems; (2) produce and obtain a wide consensus on a model architecture which can meet these basic requirements while providing flexibility to address requirements unique to a specific implementation (this consensus is necessary and almost sufficient to ensure that the results will actually be used; the remaining requirement for sufficiency is that the resulting modules be well-implemented); (3) produce, and obtain consensus on, the interface specification standards required to realize the architecture; (4) collect or produce portable software modules which instantiate the standard functions and interfaces identified in the previous steps; and (5) demonstrate these modules by arranging for their incorporation, use, and evaluation in new or expanding Code E data systems.

W90-70499 **656-61-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA INTERCHANGE STANDARDS
J. A. Johnson 818-354-7764
(656-61-02)

The purpose of this RTOP is to develop, promote, and provide standards, software, and support for storage and transfer of information in direct support of current and future NASA programs. It is based on the development of the CCSDS SFDU concept, which is supported by JPL, GSFC, and 17 space organizations of the world. The approach incorporates not only the standardization of methodologies, but the administration of implementations, supporting software, and operations concerning the administration and dissemination of data formats and software to users. The effort is divided into the following major areas: (1) development of concepts of standardization; (2) development of a testing function to ensure the validity of the SFDU construction rules, to understand the effects of various modes of transfer on the data objects, and to create methods of validating the correctness of product designs, with the results effecting additions to the standards and affecting the software design; (3) development of software utilities for SFDU product operations (includes requirements, specifications, design, coding, testing, user guides, and maintenance); (4) development of software utilities for data description and interpretation (includes requirements, etc., as above); and (5) increasing the level of user support and involvement.

W90-70500 **656-61-04**
Goddard Space Flight Center, Greenbelt, MD.
NASA SCIENCE DATA SYSTEMS STANDARDS OFFICE
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 Earth Science and Application Division (ESADS), Astrophysics Data System (ADS), and the National Research Council (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 maintain and enhance a number of specific services, under the NASA Science Data Systems Standards Office (NSDSSO), that were initiated in FY-89. The NSDSSO services fall into three major categories: standards library and on-line standards information system; new standards accreditation; and standards conformance testing and support. The standards library and information system database will be enhanced and maintained. The NASA Master Directory Directory Interchange Format (DIF) and the ESADS Data Systems Lexicon will be processed for accreditation as NASA-wide standards. A series of workshops to coordinate the convergence of standards for information exchange will be initiated. The support offices for Common Data Format (CDF) and Flexible Image Transport System (FITS) will be maintained, and the Standard Formatted Data Unit (SFDU) support office will be expanded to support the further development of the international SFDU Recommendations.

W90-70501 **656-61-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NAVIGATION ANCILLARY INFORMATION FACILITY
C. H. Acton 818-354-3869
(651-61-06; 155-20-70)

This RTOP develops and tests prototype software and data management technology, collectively called the SPICE system, 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 spacecraft-borne instruments. The work is conducted in direct response to recommendations of the NAS Committee on Data Management and Computation (CODMAC) report, and is particularly relevant as instrument complexity, instrument data volume and interest in correlative analysis grows. The work also supports the objectives of reduced mission costs through telescience. The Navigation Ancillary Information Facility (NAIF) development approach follows CODMAC recommendations by keeping the user community involved in SPICE design decisions at all levels, and by providing prototype component and subsystem capabilities to scientists for testing through use in their research. In addition, NAIF staff join with scientists to test SPICE system components and prototype applications within active flight project environments (Voyager-Uranus, Voyager-Neptune) and with datasets which are historic but still evolving (Voyager-Jupiter, Voyager-Saturn). In developing the SPICE system, NAIF concentrates on sound engineering, maintainability, portability, wide application, and the highest quality documentation for users. NAIF avoids using costly hardware and software which would not be readily available to the user community.

W90-70502 **656-61-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM - PROJECT ENGINEERING AND TECHNOLOGY
J. T. Renfrow 818-354-6347
(155-20-70; 656-61-05)

The overall objective of this RTOP is to develop, evaluate, and implement methodologies, standards, and technologies which can be used to solve the data management problem of the planetary science community and to involve the Testbed and Discipline Nodes in this effort, since these Nodes are run by working planetary scientists. It is expected that the solutions found will have applicability to other discipline divisions within OSSA. The detailed objectives and approach of this RTOP are: (1) provide the interface between the Planetary Data System (PDS) and other NASA/JPL facilities and projects - primary tasks being development of formal interface agreements with external organizations, the development of detailed data transfer agreements with the active flight missions, the development of standards and guidelines for data cataloging, access, storage, analysis and communication, the integration and exchange of technology and system development tools with related programs and the specification of facility, project, and instrument deliverables for use by the planetary science community; and (2) investigate data storage, data conversion, and data presentation options and develop system components and applicable technologies to test and validate functional requirements and serve as testbeds for technology to prove the effectiveness of new system components which will then be integrated into the operational PDS, work with representatives of other pilot and operational elements (PLDS, SFOC, NSSDC) to determine areas where PDS will lead research activities, and monitor and support programs evaluating other major technology areas.

W90-70503 **656-61-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA RESTORATION
S. K. Lavoie 818-354-5677

Valuable space science data (a National Resource) is currently stored in poor condition, on old media and is deteriorating. The Jet Propulsion Laboratory (JPL) has a large quantity of flight project data (dating from the 1960s) in storage on magnetic tape. The objectives of this RTOP are to: move all tapes (135,000) to acceptable environment as quickly as possible; preserve valuable data and make the data more accessible to the user; reduce the volume of the tapes by converting to higher density media and disposing of duplicate/worthless data; and transfer the converted tapes and archive responsibility to the planetary data system. The approach for achieving the objectives will consist of two phases: Phase 1: Definition and evaluation (2.0 years) entails recalling all tapes; organizing inventory and cataloging tapes; evaluating tape value under guidance of science data evaluation board (representatives from science and technical community knowledgable about the data); and preparing valuable data for conversion, distributing or disposing of duplicate/not valuable data. Phase 2: Conversion (3.5 years) consists of converting all valuable data to higher density media; generating catalog of tape contents; publishing task final report; and transferring tapes and archive responsibility to planetary data system.

W90-70504 **656-61-08**
Goddard Space Flight Center, Greenbelt, MD.
ESADS DISCIPLINE NODE/CLIMATE/LAND
Blanche Meeson 301-286-9282

One of the objectives 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, 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 FY-90, we plan to pursue this objective by adding significantly to the data described in the Pilot Land Data System (PLDS) inventories, by providing more thorough documentation, by improving the performance of the users environment, and by increasing the portability and modularity of the existing software. NASA's Climate Data System (NCDS) was first implemented as the Pilot Climate Data Base Management System. Data manipulation utilities and graphics tools were added, with support offered to meet the needs of researchers at GSFC, and later for researchers outside of GSFC, including university scientists. 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 (ESADS) which became effective during FY-89. NCDS has improved system performance 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)), and is working to meet the requirements for the support of future missions. In FY-90, the benefits of better communication with data set producers and other scientists and the results of integrated system testing for improved access to data will become apparent to the braoder user community. Software and hardware upgrades are planned, databases will be expanded, and new technology will be integrated.

W90-70505 **656-61-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ESADS/PILOT LAND DATA SYSTEM ENGINEERING
E. D. Paylor 818-354-2867
(677-41-03; 656-61-12; 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 support capability. It is a multi-NASA center activity led by Goddard Space Flight Center (GSFC) and currently comprised of three nodes, one at Ames Research Center (ARC), GSFC, and Jet Propulsion Laboratory (JPL). The capability is to be general, inter-center, and based to the extent possible on existing technology. This task will: (1) develop and implement JPL's node of the PLDS which is responsible for managing land science data resident at JPL; (2) continue to support the PLDS teams for developing, testing, and maintaining the overall 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 and JPL. JPL personnel will participate in the PLDS Development and Science teams. Liaison and coordination with other ongoing projects, such as the Earth Science Applications Data System (ESADS), Airborne Visible and Infrared Imaging Spectrometer/High Resolution Imaging Spectrometer (AVIRIS/HIRIS) data processing, Synthetic Aperture Radar (SAR) data processing, Thermal Infrared Multispectral Scanner (TIMS) data processing, Earth Observing System Data and Information System (EOSDIS), NASA Ocean Data System (NODS), and Planetary Data System (PDS), as well as the Office of Space Science and Application (OSSA) scientific projects will be maintained. The initial PLDS has been developed in a way which provided early capabilities to the PLDS science team and Science Working Group, while providing generic capabilities and techniques having a broader use. Requirements levied on the PLDS by these scientists were used to functionally design the system. Major upgrades/modifications to the system currently needed for operations are based on requirements gathered from a broader scientific base. Each system component at JPL is being developed in parallel with science projects, thus providing maximum utility during the development/testing of the system. JPL participation in PLDS project follows the PLDS project structure established by PLDS Project Management at GSFC.

W90-70506 **656-61-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYNTHETIC APERTURE RADAR DATA SYSTEMS
J. C. Curlander 818-354-8262

The objectives of this RTOP are: (1) to maintain and enhance the SAR Data Catalog System (SDCS) as a vital element of NASA's overall ESADS (Earth Science and Applications Data System) program; and (2) to develop standards that improve or facilitate the access and utilization of SAR data. The SDCS provides users of SEASAT SAR, Shuttle Imaging Radar (SIR-B), and aircraft SAR data with user oriented, menu-driven access to descriptive information (including a menu of acquisition parameters, global coverage maps illustrating both the total radar coverage and availability of processed imagery, and SEASAT, SIR-B and aircraft SAR image information searchable by location or any of over 80 platform, sensor, and processing parameters), and on-line capability to place orders for SAR data, and a capability to produce and deliver requested data products to users. Standard formats are being coordinated with other international agencies (e.g., ESA) through our participation in the Committee on Earth Observation Satellites (CEOS) SAR Working Group which was formed to develop international SAR format standards and product definitions for ERS-1, SIR-C, JERS-1, RADARSAT, and Eos SAR instruments. In addition, development of an SFDU structure for the CEOS SAR data product format is being developed.

W90-70507 **656-61-11**
Ames Research Center, Moffett Field, CA.
PILOT LAND DATA SYSTEM (PLDS)
G. Angelici 415-694-5947
(656-42-01)

The objective of the Pilot Land Data System (PLDS) is to establish a data and information system capable of supporting research in the land sciences being undertaken at NASA centers and associated universities. The approach is to populate databases with data and information that is useful to land scientists and to provide an effective methodology for scientists to extract the data. This work is managed by Goddard Space Flight Center. Ames Research Center (ARC) is responsible for the establishment, maintanence and update of the PLDS aircraft program data base node. ARC coordinates with other NASA centers to implement a common core of functions, including user interface, directory, catalog and inventory. In the long term, the PLDS node at Ames will manage data for all data types useful for ecosystems research, rather than only aircraft-based data.

W90-70508 **656-61-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA OCEAN DATA SYSTEM (NODS)
D. Halpern 818-354-5327
(161-40-10)

The Jet Propulsion Laboratory (JPL)-node of the NASA Ocean Data System (JPL/NODS) aims to be the U.S. leader in the archive and distribution of satellite ocean data products, emphasizing altimetry and scatterometry. For altimetry and scatterometry data sets (e.g., Topex and NASA Scatterometer (NSCAT), a wide variety of data, including interim geophysical data records (IGDR), geophysical data records (GDR), metadata and in situ measurements, will be archived. For other data sets (e.g., Advanced Very High Resolution Radiometer (AVHRR) and Special Sensor Microwave/Imager (SSM/I) non-frozen ocean data), only higher-level products will be archived. The JPL/NODS has identified several applications urgently needed by ocean scientists: to acquire NASA funded and other agency funded higher-level satellite ocean data sets; to provide data extraction services and rapid delivery of data; to provide user friendly access to information about NODS resources; to access via electronic networks to the NASA Master Directory (NMD) and inventories; to provide user friendly inventories to facilitate data granule location and ordering; to provide leadership in preparation of compact disc-read only memorys (CD-ROMs) containing single and multi-sensor ocean data; and to promote standards of classifying, documenting, and archiving data to facilitate access to data. Three activities will be emphasized in

FY-90: inventory development, coordination with flight projects and other NASA and international activities, and CD-ROM production. Geosat and AVHRR inventories will be created. An archive and data distribution management plan for TOPEX will be established. Participation in CEOS, ISSP, TNAWT, CI, AVISO and other workshops, meetings, committees will continue. CD-ROMS will be created for volume 2 of the WCTS and Geosat data will be created.

W90-70509 **656-61-13**
Goddard Space Flight Center, Greenbelt, MD.
SS FREEDOM/EOS ARCHIVE PLANNING STUDY
Joseph H. King 301-286-7355

This RTOP supports a study of the requirements to be satisfied by NASA, and in particular by NASA/EC and its principal agent, National Space Science Data Center (NSSDC), in the permanent archiving of data from the EOS program and from the Space Station Freedom. It will define these requirements in the context of an archive environment distributed across multiple federal agencies, and will define approaches to maximize data management standards to be adopted across agencies. The study supported by this RTOP will determine data volume requirements for the permanent archives, data access requirements including what data needs online accessibility, what data processing, manipulation, subsetting, reformatting, display capabilities must be provided by a permanent archive. It will determine whether HQ/EC should share project-managed data management facilities e.g., EOS Data Archive and Distribution Service (DADS), utilize NSSDC facilities, or utilize the facilities of extant or newly created discipline data centers. In any of these cases, the management responsibility of NSSDC will be clarified. Initial and recurring cost estimates will be developed.

W90-70510 **656-61-17**
Goddard Space Flight Center, Greenbelt, MD.
ASTROPHYSICS DATA SYSTEM SUPPORT
M. Van Steenberg 301-286-7354
(399-20-01)

The purpose of this project is to apply information system technologies to enable the National Space Science Data Center (NSSDC) to provide active support to the Astrophysics Data System (ADS) effort. The scope of this RTOP is divided into three parts: (1) the NSSDC will be established as a full node of the ADS, providing ADS users with access to the facilities and services of the NSSDC including approximately 30 on-line astronomical catalogs - observation logs with supporting documentation; (2) a report detailing the overall role NSSDC can play in supporting the ADS will be developed and coordinated with the ADS and its program sponsors, and will address how NSSDC should interact with NASA astronomy flight projects (COBE, IUE, IRAS, GRO, HST, etc.) and ADS elements (HESARC, NOAO, NRAO, etc.), what levels of support should be provided in the areas of data archiving, documentation, reformatting, and distribution as well as consulting services on data technologies such as media; and (3) the DAVID (Distributed Access View Integrated Database) prototype system that is now installed on a number of ADS nodes will be recoded and documented to produce a generic, portable capability to be made available to other discipline data system efforts through the Data System Interoperability program also sponsored by OSSA's Communications and Information Systems Division.

W90-70511 **656-65-01**
Goddard Space Flight Center, Greenbelt, MD.
LAND ANALYSIS SOFTWARE
Yun-Chi Lu 301-286-4093

The objective of this RTOP is to develop a portable, comprehensive, distributed image analysis system for use across micro-computer based workstation, minicomputers, and super-computers to accommodate various levels of computational requirements in the multidisciplinary environment. The approach will be to: improve the portability of the Land Analysis System (LAS) by removing VAX/VMS dependencies; implement selected LAS functions on micro- and super-computers; incorporate public domain Geographic Information System (GIS) into LAS environment with selected functions; develop mosaicking capabilities for global data sets; and to continue user support through LAS User Support Office. Expected results include a new transportable distributed LAS image processing system, independent of machines and operating environments with functionality equivalent to the baseline version of LAS. It will be released to the Coherent Optical System of Modular Imaging Collectors (COSMIC) for general distribution and will provide capabilities for mosaicking global data sets.

W90-70512 **656-65-03**
Goddard Space Flight Center, Greenbelt, MD.
GENERIC VISUALIZATION OF SCIENTIFIC DATA
Lloyd A. Treinish 301-286-9884

The objective of this research is to develop a visualization system for non-programmers to help support correlative data display and analysis for NASA sponsored research in the space and earth sciences. Such a system is the National Space Science Data Center (NSSDC) Graphics System (NGS), which is operational in the DEC VAX/VMS environment and forms a core capability for a variety of applications. In FY-90 the strategy is to expand this operational system, on a limited basis to include new visualization techniques and implementations in non-VMS environments (i.e., Unix workstations). The tools will be made available to the maximum extent possible for correlative data visualization and analysis. The NGS currently supports the NSSDC's Network Assisted Coordinated Science (NACS) system in support of the Coordinated Data Analysis Workshop (CDAW) and the NASA Climate Data System (NCDS) as well as individual NASA/GSFC scientists.

W90-70513 **656-65-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGING METHODS FOR MULTI-DIMENSIONAL SCIENTIFIC DATA VISUALIZATION FOR EARTH AND SPACE SCIENCES
K. J. Hussey 818-354-4016
(656-65-05; 677-43-21)

The objective of this RTOP will be the development of visualization technology to allow integration of scientific data from several disciplines for the analysis of multi-dimensional images, including animations at the highest useful spatial resolution. Earth scientists, planetary scientists, and astrophysicists will require several dimensions (spatial, spectral, temporal) to solve many of their problems, yet most data are represented in two dimensions. Interactive tools will be developed to properly combine and then visualize multidisciplinary data in several dimensions. A particular example (crustal geology) will be developed, but attention will be given to the generalization of techniques so that similar three-dimensional models may be constructed from comparable data sets. This work will be done in close cooperation with scientists whose data is being visualized. The approach of this RTOP will be to use a multidisciplinary task team, consisting of the scientists whose data is to be visualized, visualization specialists and image processing/computer graphics programmers. Due to the true 3-D nature of scientific data, the use of volumetric data visualization techniques will be incorporated. A specific example, a crustal-scale geologic block diagram visualization has been animated. Selected prototype procedures used to produce the animation will be generalized and made available in a workstation environment to the task scientists. This includes a scientist friendly user interface to the enhanced procedures. Additional data structures will be coregistered by extending existing techniques and development of new ones.

W90-70514 **656-65-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAPHICAL METHODS FOR SCIENCE VISUALIZATION AND DATA ANALYSIS
A. S. Jacobson 818-397-7656
(656-65-04)

The development of computers with ever-increasing power, and remote sensors with ever-increasing spatial and temporal resolution has begun to produce a flood of data which promises

to grow. This flood has special problems in all areas of data handling and comprehension. It is critically important to bring the unique speed and pattern recognition capabilities of the human eye/brain system to bear in dealing with these problems. Computer graphics is a means for accomplishing this. It can be applied to data browsing and subsetting, as well as data display, manipulation and analysis. The overall objective of this task is to apply computer graphics technologies and methods to such problems. The specific near term objective is to develop a system of tools and applications which provide the scientists the ability to graphically display and rapidly and interactively analyze multidimensional, multivariate data sets either alone or in collaboration. The goal is to derive quantitative as well as qualitative information from the data. A concept which satisfies our objectives was originated under the support of the JPL Director's Discretionary Fund. It is the Linked Windows Interactive Data System (LINKWINDS) and is an environment which can contain multiple applications for the presentation of large complex scientific data sets, and mechanisms for linking the presentations created by these applications so that they can be interactively manipulated in a series of co-varying windows for the study of trends, variations, anomalies and correlations. The development process will be an iterative one in which applications will be rapidly prototyped in the LINKWINDS environment, applied to specific data analysis tasks by users whose results are then fed back for the next stage of the development. The environment will ultimately also contain tools for allowing the user to create the applications.

W90-70515 **656-65-07**
Goddard Space Flight Center, Greenbelt, MD.
CENTER OF EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)
Jaylee M. Mead 301-286-8543

The objective of this RTOP is 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 reviews of CESDIS by the USRA Council; and to act as the interface between NASA and CESDIS.

W90-70516 **656-74-02**
Goddard Space Flight Center, Greenbelt, MD.
SOFTWARE FOR PARALLEL COMPUTING
J. R. Fischer 301-286-3465

The objective of this RTOP is to develop and enhance the user environment supporting the Space Data and Computing Division's (SDCD) massively parallel computers for the benefit of the NASA research community including the Headquarters approved scientific users. The SDCD is purchasing a commercial massively parallel computer system to replace the one-of-a-kind Massively Parallel Processor (MPP). The new machine will overcome significant limitations of the MPP by providing a greatly expanded high speed memory, a high speed disk subsystem, a high speed image display. Its hardware and system software including its subroutine library and high level language will be commercially maintained. This new system will be installed in the NASA Space and Earth Science Computing Center (NSESCC) alongside the vector processor and the IBM compatible mainframes. It will be made available to NSESCC users on the same basis as the other NSESCC machines. This RTOP will provide user support for scientific users of the new SDCD massively parallel computer. Support will included mapping of new problems to the machine architecture and custom coding of specific library routines required by users which are not otherwise available in the commercial libraries.

W90-70517 **656-74-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS
J. E. Solomon 818-354-2722
(656-65-04; 656-65-05)

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 a concurrent image processing executive (CIPE) software system. A second major objective 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-users. The final objective within this RTOP 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 High Resolution Imaging Spectrometer (HIRIS), Moderate-Resolution Imaging Spectrometer (MODIS), and Synthetic Aperture Radar (SAR) instruments. The task elements described in this RTOP lead to the establishment of a science analysis testbed which will be used to develop and demonstrate advanced concepts in scientific computing and visualization for EOS-era remote sensing science. The approach to be taken in meeting the RTOP objectives consists of the following elements: (1) implementation of concurrent image processing facility with hypercube (MIMD) and systolic array (SIMD) technology, coupled with a high performance workstation host; (2) development of a concurrent image processing executive (CIPE) software with a system layer, applications layer, and user interface layer; (3) development of applications specific concurrent algorithms and software for large-scale multi-sensor, multispectral image analysis and visualization operations; and (4) hardware/software integration into a science applications testbed facility with interface protocols for a multi-layer network environment.

Mission Operations and Data Analysis

W90-70518 **665-31-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SIR-C SCIENCE TEAM SUPPORT
D. L. Evans 818-354-2418

The objectives of the work are to provide funding and science support for selected Shuttle Imaging Radar (SIR)-C/X-Synthetic Aperture Radar (SAR) investigators. This RTOP covers several phases of Science Team support, including contract management, SIR-C prototype aircraft data acquisition, and mission planning and calibration support.

Search and Rescue Mission

W90-70519 **669-30-01**
Goddard Space Flight Center, Greenbelt, MD.
SEARCH AND RESCUE ADVANCED TECHNIQUES
W. A. Hembree 301-286-8332

The objective is to apply aerospace technology to the support of the search and rescue community, beyond the now operational

COSPAS/SARSAT (C/S) system. Four objectives are: (1) enhance (C/S) system by reducing present undesirable features; (2) demonstrate system that can save more lives by detecting distresses with no transmitting distress beacon; (3) demonstrate near-instantaneous alerting system using Geostationary Operational Environmental Satellite (GOES) satellites, and propose geosynchronous satellite system for near-instantaneous distress locating; and (4) demonstrate ground system techniques for objectives 1 and 2.

Climate Research

W90-70520 **672-00-00**
Langley Research Center, Hampton, VA.
CLIMATE RESEARCH
John T. Suttles 804-864-5685

The 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: (1) continue 48-inch ground-based and airborne Light Detection and Ranging Device Optical Radar (LIDAR) measurements to extend the climatology of aerosol distributions and conduct cirrus and stratospheric polar cloud experiments; and (2) conduct analysis of satellite data Geostationary Operational Environmental Satellite (GOES), LANDSAT and Advanced Very High Resolution Radiometer (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.

W90-70521 **672-00-00**
Ames Research Center, Moffett Field, CA.
MULTIDIMENSIONAL STUDIES OF TROPOSPHERIC CLOUDS
D. L. Westphal 415-694-3522

The objectives of this work are: (1) to study the atmospheric structure, dynamics, and cloud fields during the First International Satellite Cloud Climatology Project Regional Experiment (FIRE) cirrus field programs; and (2) to develop parameterizations of clouds and their radiative effects for use in mesoscale models and to validate these parameterizations using measurements made during the Cirrus Intensive Field Observation periods. The approach is to couple numerical models of atmospheric dynamics, cirrus cloud microphysics, and radiative heat transfer to form a unique forecast model capable of simulating observed midlatitude weather systems. The present version of this model (without cloud microphysics) will be used to produce four-dimensional datasets for the Cirrus Intensive Field Observation periods for use by researchers in interpreting their field data and in understanding the synoptic and mesoscale dynamics. Additionally, the impact of high-density radiosonde data or profiler data on meteorological analyses and forecasts will be investigated. These model simulations will be compared with observations and will evaluate the ability of the model to simulate the observed cloud fields, radiative fluxes, and the net radiative budget for the domain. Improvements to the model's cloud parameterization will be developed, tested, and validated using data from the Cirrus Intensive Field Observation periods.

W90-70522 **672-10-00**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE DATA BASE DEVELOPMENT
Albert Arking 301-286-7208
(672-20-00; 672-30-00; 672-40-00; 672-50-00)

The objective of this RTOP is to make available and facilitate the use of space acquired global data sets for climate research applications. The approach will be to: (1) collect, catalog, and archive data sets from NASA research satellites and from operational satellites where such data are needed by NASA and NASA-supported investigators; (2) incorporate such data, including newly processed data from Earth Radiation Budget Experiment (ERBE) and International Satellite Cloud Climatology Project (ISCCP), into the NASA Climate Data System and insure maximum access by the climate research community.

W90-70523 **672-10-02**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL CLOUD CLIMATOLOGY ISCCP OPERATIONS
William B. Rossow 212-678-5567

The objective of this RTOP is to develop and apply techniques of extraction of cloud optical properties to satellite observations to produce cloud climatology data sets. The approach will be to: (1) participate in the International Satellite Cloud Climatology Project (ISCCP) as the Global Processing Center to produce a twelve year global cloud climatology; (2) participate in data and analysis comparisons to validate the global climatology. The expected results include: (1) continued processing of radiance and correlative data with a time lag of 9 to 12 months; (2) completed processing of first four years of cloud data; (3) continued comparisons to pilot study and field experiment data to validate results; and (4) completed first intercomparison between ISCCP and ground-based cloud climatology.

W90-70524 **672-22-00**
Ames Research Center, Moffett Field, CA.
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 gain an understanding of the interaction of radiation and clouds through 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.

W90-70525 **672-22-06**
Goddard Inst. for Space Studies, New York, NY.
EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES
William B. Rossow 212-678-5567

The objectives of this RTOP are to: (1) test cloud analysis algorithms, particularly those used by the International Satellite Cloud Climatology Project (ISCCP) at its polar regions, and develop new cloud algorithms; and (2) develop analysis methods to infer cloud-radiative feedbacks from the ISCCP data. The approach will be to: (1) test ISCCP results in polar regions against other satellite cloud algorithms and multi-spectral radiative analysis of AVHRR data; (2) test ISCCP results by radiative model comparisons to 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 to: (1) continue further studies of ISCCP cloud algorithms in the polar regions; (2) continue comparisons of radiative analysis of cirrus and marine stratus clouds covering a wide range of spatial resolutions, viewing geometries, and portions of the spectrum; (3) continue comparison of ISCCP-derived, ERBE and climate model radiation budgets; and (4) derive surface radiation budget and infer cloud-radiative feedbacks from ISCCP data.

W90-70526 **672-31-00**
Ames Research Center, Moffett Field, CA.
AEROSOL FORMATION MODELS
O. B. Toon 415-694-5971
(672-32-99)

The objective of the work is to gain a better understanding 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 is being developed for use in exploring cloud formation processes and their impact on cloud radiative properties.

W90-70527 **672-31-03**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL CLIMATE MODELING
James Hansen 212-678-5619

The objective of this RTOP is 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. The approach will be to 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 II as a control for these experiments. The remaining approach will be to use the current Model II 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 forcing changes at a realistic rate on decadal time scales.

W90-70528 **672-31-12**
Goddard Inst. for Space Studies, New York, NY.
EXTENSION AND TESTING OF THE HYDROLOGIC PARAMETERIZATION IN THE GISS ATMOSPHERIC GCM
Anthony D. DelGenio 212-678-5588

The overall objective of this work is to test and improve the capability of the Goddard Institute for Space Science (GISS) general circulation model to reproduce critical aspects of global hydroclimatology, via the development of new diagnostic methods for evaluating the cycling of moisture in the model and the implementation of subgrid-scale fluctuations in the model's ground hydrology parameterization. Principal elements of the approach are: (1) formulation and testing of the effects of subgrid-scale soil moisture variations in the general circulation model (GCM) ground hydrology parameterization based on observed precipitation probability density functions and field studies of storm catchment areas; (2) comparison of the simple scheme with subgrid-scale variability with a more complex scheme which includes realistic soil and vegetation components; and (3) development of a global one-dimensional analog of the GISS GCM that captures the essential radiative and convective processes of a global climate.

W90-70529 **672-32-00**
Ames Research Center, Moffett Field, CA.
CLIMATE MODELING WITH EMPHASIS ON AEROSOLS AND CLOUDS
J. B. Pollack 415-694-5530
(672-31-00; 672-22-00)

The objectives of this RTOP are the following. 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 its 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., Stratospheric Aerosol Measurement (SAM), Stratospheric Aerosol and Gas Experiment (SAGE II) 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 approaches of the RTOP are as follows: 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 particle formation are utilized for making the climatic assessments, including simulations with a three-dimensional climate model.

W90-70530 **672-40-00**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE OBSERVATIONS
Albert Arking 301-286-7208
(672-10-00; 672-20-00; 672-30-00; 672-50-00)

The objective of this RTOP is to determine past and present solar variations and their potential impact on climate. The approaches to this RTOP are to develop experimental techniques for observing changes in solar diameter, and develop theoretical and empirical models relating changes in solar luminosity to changes in solar diameter.

W90-70531 **672-50-03**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE PROGRAM SUPPORT
Albert Arking 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 broadly based NASA climate research program, which in turn, involves a substantial contribution to the National Climate Program. The approaches to this RTOP are to: (1) develop recommendations for climate research initiatives in support of NASA and GSFC climate research objectives; (2) provide planning 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 process studies, with particular emphasis on clouds and earth/atmosphere radiation processes; (5) provide support for annual National Climate Program reports to Congress, annual science review, etc.; and (6) arrange for ad hoc science working groups, advisor panels, etc.

W90-70532 **672-60-00**
Goddard Space Flight Center, Greenbelt, MD.
IR LARGE APERTURE INTEGRATING SOURCES STUDIES
Albert Arking 301-286-7208

The objective of this RTOP is to provide laboratory calibration capability for atmospheric and aerosol studies in the near infrared portion of the reflected solar spectrum; improve absolute accuracy of these calibrations; and track calibration accuracy and precision

of ground calibrations. The approaches to this RTOP are to implement and document improved ground calibrations of large aperture integrating sources; and implement calibration scale based on self-calibrating diodes with uncertainty near 1 percent absolute.

W90-70533 **672-90-20**
Ames Research Center, Moffett Field, CA.
EARTH OBSERVATIONS COMMERCIAL APPLICATIONS PROGRAM
J. S. Salute 415-694-5596
(142-20-37)

The objective of this RTOP is to create partnerships between NASA, U.S. private sector, U.S. educational and other non-profit organizations, and other U.S. government agencies to increase commercial usage of NASA developed remote sensing technology. This includes providing operational users with access to advances in remote sensing techniques and technologies for improved services and operations, while fostering the utilization of remote sensing for national economic benefit. The approaches taken within this RTOP include: (1) using proven techniques and data analysis methodology to address newly defined environmental analysis problems; (2) extrapolating proven techniques developed to address a specific discipline requirement to new disciplines or research areas; and (3) developing new spatial data management and analysis techniques for applying remote sensing and geographic data to practical environmental problems.

Stratospheric Air Quality

W90-70534 **673-00-00**
Langley Research Center, Hampton, VA.
STRATOSPHERIC AIR QUALITY
William L. Grose 804-864-5820

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 our understanding of the stratosphere and potential changes to its composition and structure. Specific tasks include: (1) interpretation of chemical transport processes in the stratosphere using constituent and temperature data from satellite-based experiments; (2) 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; and (3) investigate stratospheric dynamics and transport processes using a 3-D circulation/transport model and global sets of satellite data.

W90-70535 **673-41-01**
Goddard Space Flight Center, Greenbelt, MD.
ANALYSIS OF UPPER ATMOSPHERIC MEASUREMENTS, AND 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 our 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 to this RTOP 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. Long term climatological data sets for the study of annual and interannual variations and their driving mechanisms, plus responses to solar activity are assembled. A long term ultraviolet solar irradiance data base to better define possible mechanisms of solar variability is collected and analyzed.

W90-70536 **673-41-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TRANSPORT BY PLANETARY WAVES IN THE STRATOSPHERE
L. S. Elson 818-354-4223

The major theme of the proposed work is that long-lived (more than two weeks) planetary waves have the potential for transporting significant amounts of atmospheric species, heat, and momentum despite the fact that their amplitudes are sometimes smaller than those of the planetary waves which dominate transient features such as sudden warmings. In the past, the important issues of understanding the mechanisms which produce planetary waves and understanding the effects of these waves on the transport of ozone have been dealt with by using simple models which have somewhat arbitrarily chosen input parameters which are argued to be representative of the real atmosphere. The work proposed here seeks to maximize the incorporation of observations into a suite of models, to use the models and data to identify the mechanisms which produce planetary waves, and to understand quantitatively the role that such waves play in the transport of ozone and other species. It is important to distinguish this effort from similar attempts to model the entire circulation by incorporating observations into general circulation models used in a forecast mode. The effort described here seeks to examine only selected processes which are expected to be dominant based on observations.

W90-70537 **673-42-00**
Ames Research Center, Moffett Field, CA.
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 and mesoscale dynamics in the lower stratosphere. Of particular interest are: (1) stratosphere-troposphere exchange; (2) lateral and vertical mixing and exchange in the lower stratosphere; and (3) dehydration mechanisms in the lower tropical stratosphere. Specifically, aircraft, radiosonde, and satellite data from the 1987 NASA field experiment in Micronesia and the 1987 AAOE field experiment in Antarctica will be analyzed to establish the presence, during the experimental period, of various potential mechanisms of stratosphere-troposphere exchange, lower stratosphere transport, and tropical dehydration.

W90-70538 **673-61-00**
Ames Research Center, Moffett Field, CA.
STRATOSPHERIC DYNAMICS AND PARTICULATES
L. Pfister 415-694-3183
(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. Also included is a meteorological support task to organize and distribute data from various field programs. Meteorological analysis and satellite data acquisition are also included.

W90-70539 **673-61-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MESOSPHERIC THEORY
R. W. Zurek 818-354-3725

The objective of this RTOP is to better understand the interaction of photochemistry and mass transport in the terrestrial upper atmosphere. A 2-D radiative-dynamic-photochemical model has been developed in a continuing collaboration with M. Allen and D. Crisp (JPL) and Y. Yung and R.-L. Shia (Caltech). The current stratosphere model will be applied to the analysis of the processes controlling the concentrations of photochemically and/or radiatively important minor constituents of the stratosphere and mesosphere, as revealed by spaceborne (e.g., Limb Infrared Monitor of the Stratosphere (LIMS) and Atmospheric Tracs Molecules Spectroscopy (ATMOS) and airborne (e.g., High-resolution IR Spectrometers) remotely sensed data.

W90-70540 **673-61-07**
Goddard Inst. for Space Studies, New York, NY.
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 for achieving the objectives will consist of 3-D modeling of the troposphere/stratosphere/mesosphere system to delineate climate change influence on the stratosphere; results saved for use with photochemical models. Expected results include 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.

W90-70541 **673-61-09**
Marshall Space Flight Center, Huntsville, AL.
UPPER ATMOSPHERIC THEORY AND DATA ANALYSIS
G. S. Wilson 205-544-1628

The objective of this RTOP is to perform fundamental studies aimed at improving our understanding of the dynamics of Earth's upper atmosphere. The approach will be 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.

W90-70542 **673-62-00**
Ames Research Center, Moffett Field, CA.
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 heterogeneous 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.

W90-70543 **673-62-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRATOSPHERIC RADIATIVE PROCESSES AND THE 2-D CHEMICAL TRACER TRANSPORT CIRCULATION
D. Crisp 818-354-9617

The distribution of O3 and other trace gases is most strongly influenced by meridional transport at levels in the middle and lower stratosphere. General Circulation Model (GCM) experiments show that the transport at these levels can be approximated by the diabatic circulation, which can be derived diagnostically from the net radiative heating rates. We propose to develop a hierarchy of fast, accurate methods for finding stratospheric net radiative heating rates. These heating rates will be used to specify the transport circulation in the Caltech 2-D Chemical Tracer Transport Model. We also propose to expand the scope of this RTOP to include direct collaboration with the 2-D modeling groups at Lawrence Livermore and the University of Washington at Seattle. These new activities will focus on the development of fast, accurate methods for finding net radiative heating rates throughout the stratosphere. The existing Caltech radiative transfer model accounts for all important radiative processes at levels between the surface and 65 km. A Voigt Quasi-Random model is used to find the absorption by gases, and a delta-Eddington/Adding method is used to find fluxes and heating rates in absorbing, scattering atmospheres. This model agrees well with an accurate line-by-line model, but it requires much more computing time than the simpler models used by other 2-D modeling groups. A recent intercomparison of thermal cooling rates from several 2-D models shows that these simpler models sometimes produce cooling rate errors as large as 40 percent for identical input atmospheres. Errors this large could compromise the validity of ongoing 2-D stratospheric modeling efforts. We propose to address these problems by developing and implementing a new class of Correlated-k model. This model should provide the speed and accuracy needed in a broad range of stratospheric tracer transport modeling applications.

W90-70544 **673-64-04**
Goddard Inst. for Space Studies, New York, NY.
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 21-layer tracer model, a stratospheric chemical tracer model based on experience with similar tropospheric models, will be developed and validated. The chemical model will be limited to photolytic destruction of species such as CFCs and N2O completed. Comparison will be made with observations (in preparation). Stratospheric chemistry includes the parameterization of a complete ozone chemistry for use in the stratospheric tracer model. Limited, linearized ozone chemistry is applied to study the Antarctic ozone hole (completed). Relying on the 21-layer GCM simulation of CO2 and O3 perturbations to the stratospheric circulation, chemicals are used to assess the impact on lifetimes of long-lived tracers and on ozone.

W90-70545 **673-64-05**
Goddard Space Flight Center, Greenbelt, MD.
STRATOSPHERIC CIRCULATION MODELING WITH CHEMISTRY
M. R. Schoeberl 301-286-5819
(673-41-00)

The objectives of this RTOP are: (1) provide a framework to understand the natural stratosphere and its response to external perturbations; and (2) to enhance our 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 include improved understanding of the stratospheric radiative-chemical-dynamic system.

Space Processing Science and Spacelab Payload Development

W90-70546 **674-21-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EFFECT OF CONVECTION AND GRAVITY ON THE GROWTH OF PROTEIN CRYSTALS
P. J. Shlichta 818-354-3339

Although qualitative micro-g and high-g experimental results indicate that protein crystal growth is adversely affected by gravity, there is to date no theoretical explanation for this effect and virtually no quantitative data. The proposed research is aimed at understanding the mechanisms of the effect of gravity on the growth of protein crystals so that the advantages of microgravity can be optimally exploited. A preliminary theoretical analysis indicates that these effects might be explained by assuming that convection causes orientation and/or deformation of protein molecules in solution, reduces the attachment probability at the growth interface, or causes macroscopic fluctuations of growth conditions. The proposed research will test and prioritize these alternative explanations by: (1) generating quantitative data on the relation between gravity, convection, growth rate, crystal size, and perfection in representative proteins, (2) determining the effect of centrifugal fields on growth rate, terminal size, and crystal perfection, and (3) assessing the effect of shear flow on the orientation and/or deformation of protein molecules in solution and the effect of vibration and impurities on growth rate and perfection. By a series of iterations, the experimental data will be used to refine the theoretical models, which will then be used to define subsequent experiments. It is expected that the proposed research will culminate in the definition and proposal of decisive microgravity experiments in the Advanced Protein Crystal Growth Facility (APCGF).

W90-70547 **674-21-05**
Lewis Research Center, Cleveland, OH.
ELECTRONIC MATERIALS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The plan for FY-90 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 processes. The objectives of this project include achieving a quantitative understanding of crystal growth processes, identifying convective effects, and obtaining optimal process control parameters for desired crystal structure and properties. We concentrate on physical vapor deposition and Bridgman growth and typically use high temperature transparent furnaces to allow observation of growth of technologically significant materials. Dr. Walter Duval has been investigating the influences of g-jitter on mixing of fluids of similar viscosity but differing density. His published work shows that the effects depend highly on frequency and also on container size, shape and system kinematic viscosity. In cooperation with Westinghouse, Dr. Duval and Bruce Rosenthal will continue with solidification studies of lead chloride, an electro-optic material; they will investigate additions of silver chloride, an alloy chosen to mark both segregation and convection effects. Dr. Duval will continue also his work on vapor transport, especially the behavior of mixed molecular weight gases. He will complete work on modelling the distribution of gases in thermal gradients typical of physical vapor deposition apparatus. We anticipate monitoring a grant with Drs. Rosner and Keyes of Yale following up an important finding of a grant initially funded through the Microgravity Materials Science Lab. They have identified a thermal gradient driven flow which appears to be the major contributor to convection in pressure ranges encountered in physical vapor transport; understanding this flow is imperative to correct interpretation of a thermal gradient. Dr. Duval will continue to monitor a contract concerning vapor growth of crystals in cells including effusion holes. He also will serve as the Lewis point of contact for an SBIR with Brimrose Corporation, involving the growth of laser guidance crystals and another with Microgravity Research Associates involving liquid phase epitaxy as a means to grow potential new semiconductors. Also working in house, Dr. Mohamed Kassemi will extend his modelling of radiative thermal transport in vapor deposition to include non-transparent gases. Prior work has shown that radiative heat transfer is a major competitor to conduction and convection on earth and may even dominate conduction in microgravity.

W90-70548 **674-21-06**
Langley Research Center, Hampton, VA.
MORPHOLOGICAL STABILITY AND KINETICS IN CRYSTAL GROWTH FROM VAPORS
J. F. Creedon 804-864-6033

The objective of this research is to support ground-based research in fundamental theory of crystal growth from vapors. The approach is to gather definitive experimental data for the kinetic and fluid flow conditions that lead to morphological instability. These studies will be performed on simple systems that will allow observation.

W90-70549 **674-21-08**
Marshall Space Flight Center, Huntsville, AL.
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 a crystal: (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.

W90-70550 **674-22-05**
Lewis Research Center, Cleveland, OH.
LERC MICROGRAVITY SCIENCE AND APPLICATIONS
Richard J. Parker 216-433-2871
(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The overall objectives of the Lewis Research Center (LeRC) Microgravity Science and Applications program are to: (1) improve the understanding of the role of gravity in combustion science, materials science and processing, and fluid physics and chemistry; and (2) define areas of potential applications for low-gravity processing using earth-based or space facilities. In the materials science area, work is being carried out in the disciplines of electronic materials, metals and alloys, and glasses and ceramics. The general approach is to conduct both experimental and theoretical research on physical phenomena in order to define governing mechanisms, validate models, and obtain unique data unavailable to date because of the limiting and masking efforts of gravity. A three-fold effort will be employed: (1) a microgravity experiment definition effort will be conducted in collaboration with the academic and industrial scientific communities; (2) experimental and/or theoretical research projects will be carried out in selected areas utilizing ground-based laboratories including the LeRC Microgravity Materials Science Laboratory and the available ground-based reduced gravity facilities; and (3) flight experiment conceptual designs shall be prepared and experimental apparatus and instrument definition activities shall be conducted.

W90-70551 **674-23-08**
Marshall Space Flight Center, Huntsville, AL.
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.

W90-70552 **674-24-02**
Goddard Space Flight Center, Greenbelt, MD.
CRITICAL TRANSPORT PROPERTIES
S. H. Castles 301-286-5405

The objective is to obtain accurate thermodynamic data sufficiently close to a critical point to allow the accurate determination of the associated critical exponents. The approach is to find a critical point experiment in fluid helium with relatively short time constants and then perform the experiment in low gravity (to decrease density gradients in the sample). The short time constant is required because a shuttle attached payload, with limited experiment time, is envisioned. Liquid helium is used because it provides an easily purified working fluid (no other media provides such clean data) and it offers an abundance of critical points which are generally well studied theoretically.

W90-70553 **674-24-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
D. D. Elleman 818-354-5182

The fluid dynamics and transport phenomena consist of two tasks. The principal objectives of each of the tasks are discussed below. First, the Collision and Coalescence of Free Drops Task described in this RTOP will be carried out by Professor T. G. Wang under a contract to Vanderbilt University. The objective 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. Second, the Coherence Length Task described in this RTOP will be carried out by Professor R. Donnelly under a contract to the University of Oregon. The objective is to study finite size effects in a thermodynamic quantity that is diverging near a critical point. In particular, it is intended to measure the expansion coefficient of liquid helium both below and above the lambda transition in a well characterized geometry. This data should provide a stringent test for renormalization group theory, especially regarding proper boundary conditions. The experiments will be conducted by measuring the changes in the dielectric constant of liquid helium near the lambda transition using a reentrant LC microwave cavity.

W90-70554 **674-24-05**
Lewis Research Center, Cleveland, OH.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of the activities covered by this RTOP is to expand our understanding of 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 using reference-fluids mean ambient temperatures are chosen for initial modeling and experimental work before proceeding to 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 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. 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.

W90-70555 **674-24-08**
Marshall Space Flight Center, Huntsville, AL.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
B. G. Bass 205-544-7756

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.

W90-70556 **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 principal objectives of each of the tasks are discussed below. The Electrostatic Containerless

Processing Technology Task objective is the 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: (1) sample charge regulations by electron beam; (2) levitation capability of high density samples in one-g (3) processing of levitated samples up to 2000 C in vacuum using a focused radiator; (4) electron beam heating technology for levitated samples; (5) sample rotation and oscillation in a vacuum; and (6) measurements of thermophysical properties at high temperatures. The Containerless Studies of Nucleation and Undercooling Task objectives are to utilize containerless manipulation technologies to perform: (1) undercooling and heterogeneous nucleation experiments on low melting pure metals and alloys and organic compounds and glass formers; (2) measurements of the physical properties of undercooled melts; and (3) determination of the effects of solidification rate on the solute distribution in initially undercooled melts of aluminum alloys. Experimental methods are based on ultrasonic and electrostatic levitation techniques. The Metallic Glass Research in Space Task will be conducted under a contract with W. Johnson at the California Institute of Technology. The task objective is to develop an experiment for determining the thermodynamic properties of liquid metallic alloys and glasses from temperatures ranging below the glass transition temperature up to and above the melting line. The scientific objectives include: (1) measuring the heat capacity and entropy as functions of temperature and relating these data to observed crystal nucleation rates in the undercooled regime; (2) testing the validity of models for the crystal/liquid interfacial energy and their relationships with models for maximum undercooling of the melt and glass formation; and (3) relating the data to the Kauzmann and inverse Kauzmann arguments for locating the glass transition and ultimate stability limits for superheated crystals. The Multimode Acoustic Research Task objectives are: (1) to develop theoretical acoustic models of new multimode classes of acoustic levitation; (2) to provide experimental validation of these models; and (3) to investigate novel methods of sample levitation, manipulation, and heating. These 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 use these levitation techniques in high temperature containerless materials processing studies.

W90-70557 **674-25-05**
Lewis Research Center, Cleveland, OH.
METALS AND ALLOYS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of this project is to conduct fundamental research on transport behavior of liquid metals to better understand such phenomena as nucleation, pattern selection during solidification, phase separation, diffusion, coarsening, and segregation. Extensive use is made of model materials such as lead-tin alloys and transparent organic analog systems. The ultimate goal is to use this understanding to improve current or develop new theories, models, and ground based materials and processes. The experience gained also contributes to preparation of materials processing in space, e.g., welding or space mineral processing. Near term targets include definition of parameters for space based cellular and dendritic solidification experiments, critical re-examination of published work to determine reasons for discrepancies between existing models and theories for dendritic and cellular growth, development of quantitative techniques for observing transparent crystal growth, evaluation of potential of bulk undercooling as a microgravity process, and examination of the zone melting technique for application to advanced metallic materials. This effort is conducted via experiments and modelling with the goal of performing critical experiments only in the microgravity environment. Past work has shown that existing models for pattern selection in cellular and dendritic solidification are not consistent with one another or with experiments in the range of solidification rates where distinction is possible. It has further been shown that earth based experiments are uniformly flawed by the presence of convection and that microgravity experiments are necessary to obtain valid data for comparison. In work on bulk undercooling it has been shown that large samples can be effectively undercooled; a dependence on composition has been illustrated entirely similar to the dependence shown by isolated droplets. One mechanism for macrosegregation has been elucidated qualitatively, and quantitative work is underway. Transparent system work has been extended to the more interesting and pertinent case of directional solidification of alloys. Ground based work contributes to definition of near term and advanced microgravity facilities. This program builds on extensive OAST Code R and T funded research at Lewis in the areas of solidification and processing of advanced high temperature alloys. In addition to in-house efforts, a number of proposals are carefully evaluated each year, and resulting grants are monitored.

W90-70558 **674-25-08**
Marshall Space Flight Center, Huntsville, AL.
METALS AND ALLOYS
P. A. Curreri 205-544-7763

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 both 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 infeasible 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 a 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.

W90-70559 **674-26-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLASS RESEARCH - GLASS FORMING ABILITY AND CRYSTALLIZATION OF GLASS
A. D. Morrison 818-354-7200

The overall objectives of this RTOP are: (1) to establish the scientific framework; (2) to provide a data base for the evaluation and interpretation of microgravity-performed glass experiments through ground-based experimentation and theoretical modeling; and (3) to employ ground-based levitation facilities for testing the feasibility of such microgravity experiments. In this program, experimental studies concerning nucleation and crystallization behavior of glasses and theoretical studies involving mathematical modeling for the calculation of critical cooling rates will provide data for interpretation of space experiments. The following specific objectives will be addressed: (1) to understand the relative importance of intrinsic and extrinsic factors in setting the practical glass-forming limits of selected compositions; (2) to develop models for the interpretation of ground-based and flight experiments; and (3) to assess the utility of performing containerless glass-forming experiments on selected compositions.

W90-70560 **674-26-08**
Marshall Space Flight Center, Huntsville, AL.
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. Recent attention drawn to containerless processing by the Microgravity Science and Applications (MSA) program has served to focus these activities and demonstrated its usefulness to a wide variety of research disciplines. The technology of containerless processing is emerging from isolated experiments investigating individual research tasks to a 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 several oxide 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. Containerless Processing has been identified by the Glass and Ceramics Discipline Working Group as a high priority technology item. Containerless processing in space requires low-level levitation forces to compensate for microgravity acceleration and to maintain position of the sample. The central purpose for containerless processing is the elimination of extraneous effects from contact with solid containment walls. The implementation of appropriate experiments will involve the following: (1) 34 and 100 m drop tubes at MSFC providing 2.6 to 4 seconds of free fall for solidifying molten droplets up to several millimeters diameter; (2) a single-axis acoustic levitator has been developed which uses a high-Q driver with a single resonant frequency for experiments up to 500 C in one-g; (3) a three-axis, six-drive acoustic levitator involving three mutually orthogonal drivers which produce a three-dimensional sound field (spherical energy well) in a tuned cavity; and (4) single-axis aerodynamic levitation using a jet of air from a carefully designed nozzle to suspend certain high surface tension, highly reactive samples in one-g to temperatures in excess of 2000 C.

W90-70561 **674-27-05**
Lewis Research Center, Cleveland, OH.
MICROGRAVITY MATERIALS RESEARCH LABORATORY
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of this project is to maintain and operate a dedicated, well equipped laboratory for the performance of ground based studies in support of the Microgravity Science and Applications Division flight program. This laboratory is open to scientists from academia, industry, and government. It contains equipment and facilities for simulation and emulation of some aspects of the microgravity environment as well as apparatus chosen to imitate flight apparatus. It is staffed by a small group of engineers and technicians providing a varied background in materials, chemistry, computer science, electrical engineering, and physics. Specialized equipment in the Microgravity Materials Science Laboratory (MMSL) include an electromagnetic levitator, the bulk undercooling apparatus, a vacuum welding chamber, the Diffused Metal Oxide Semiconductor emulator, a number of electro-optic materials Bridgman furnaces, the isothermal dendritic growth apparatus, a high temperature directional solidification furnace, a transparent analog solidification furnace, glass melting and processing apparatus, high temperature viscosimetry, a hot stage microscope, a laser light scattering apparatus, and extensive computational facilities. The MMSL includes a specialized metallographic laboratory. Under development in the MMSL are means of quantitatively tracking fluid flow in three dimensions, means of determining concentration vs. position in physical vapor transport, definition of optimum microgravity mixing techniques for application to advance generations of flight furnaces, computational techniques for handling free surfaces, and completion of a room to house the computational facilities. In terms of interaction with industry and academia it appears that the greatest need over the next decade of flight experiments will be in the area of computational simulation of fluid flows; we are concentrating our investment in responding to that need. The approach is to adapt to the greatest extent possible general purpose codes developed in industry or academia. Codes are combined in house to provide complete descriptions of fluid flow problems. Development of code is undertaken to address problems others have avoided including radiative heat transfer and involvement of free surfaces as boundaries. In contrast to the usual academic approach the codes are kept as general as possible to ensure applicability to new materials and geometries. The Computational Materials Science Laboratory within the MMSL should become the central laboratory for the numerical exposition of materials related flight experiments. We have already applied the existing capability to microgravity Bridgman growth of opaque liquids (GTE GaAs) and to chemical vapor deposition of silicon, including radiative heat transfer effects.

W90-70562 **674-28-05**
Lewis Research Center, Cleveland, OH.
GROUND EXPERIMENT OPERATIONS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

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. Ground experiment operations include: (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 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.

W90-70563 **674-28-08**
Marshall Space Flight Center, Huntsville, AL.
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, and KC-135 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.

W90-70564 **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.

W90-70565 **674-29-08**
Marshall Space Flight Center, Huntsville, AL.
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: (1) making them aware of the research opportunities offered by the MSA program; (2) stimulating their interest and active involvement in the program; (3) gauging their response to the scientific results being obtained by the program; (4) identifying research areas in which the program should concentrate; (5) initiating in-house research activities in selected topics pertinent to the MSA program; and (6) 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 with this documentation included in the NASA Headquarters data base for access to the scientific community, NASA Headquarters MSAD, and other NASA centers.

Geodynamics Research and Technology Development

W90-70566 **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 approaches to the RTOP are to: (1) pursue research aimed at determining the lithosphere's present state and evolution and its physical properties, determine the large-scale structure and magnetization contrast between the continental and oceanic lithosphere; (2) conduct studies of the measurements and systems necessary for future geophysical and geodetic measurements of the earth and planets; (3) determine the relationships between petrogenesis and tectonics; (4) provide technical and administrative management for grants and contracts in geodynamics and conduct studies of satellite altimetry over inland seas; (5) prepare and exercise geodynamics management data base; (6) conduct geodetic simulations of spaceborne laser ranging measurements and develop finite element models of earth dynamic processes; (7) study end-to-end Geodynamics Laser Ranging System requirements; (8) study lithospheric, flexural based on gravity-topography coherence; and (9) develop models of subduction zone tectonics.

W90-70567 **676-10-11**
Goddard Space Flight Center, Greenbelt, MD.
SATELLITE GEODETIC TECHNIQUE DEVELOPMENT
David E. Smith 301-286-8671

The objective of this RTOP is 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, the contribution that Lageos 3 in a polar or complementary orbit to Lageos 1 will make to satisfying long-term objectives in the solid-earth science program, and the development of techniques for the analysis of very high precision gravity gradiometer data from the Superconducting Gravity Gradiometer Mission (SGGM).

W90-70568 **676-30-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH STRUCTURE AND GEOPHYSICS
C. F. Yoder 818-354-2444

A wide range of geophysical investigations are proposed, including analysis of tectonic processes (focused on brittle/ductile deformation along the Pacific-North American plate interaction zone) and topography of the core mantle boundary and its connection with decade scale changes in earth rotation. The two major research elements covered here are: (A) TECTONIC PROCESSES: An integrated research approach is emphasized, combining quantitative modelling and qualitative synthesis of diverse data types. The principal tasks include: (1) synthesis of geologic, tectonic, geophysical, and geodetic data to develop kinematic models of block rotations and translations; (2) investigation of block rotation mechanisms within the brittle crust and complex motions occurring within the ductile lithosphere at depth along plate boundaries; (3) measurement of paleomagnetic declination throughout the Mojave block to ascertain kinematic reconstructions of rotational components of motion; and (4) application of a strike-slip/thrust fault semi-analytic technique to study crustal motions within the Transverse Ranges and the adjacent regions being monitored by space geodetic measurements. (B) TOPOGRAPHY OF THE CORE MANTLE BOUNDARY: The seismic phases P, PKP, PKIKP, PcP, and P sub diff shall be examined for the possibility of a boundary layer in the lowermost mantle (D'). In addition the shear phases S and SKS will also be analyzed for the shear properties of this layer. The resulting CMB topography model will be reanalyzed to allow the LOD date to constrain the parameters of this layer.

W90-70569 **676-40-02**
Goddard Space Flight Center, Greenbelt, MD.
GEOPOTENTIAL FIELD (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 processes in the core which are responsible for generation of that field, and the conductivity of the mantle through which the time varying field passes; to investigate core-mantle coupling (mechanical, electrical, thermal) and its effect on Earth rotation and mantle convection, 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 FY-89 a total rewrite and modernization of the field modeling software was accomplished; an error analysis formulation, accounting for fields not included in the solution, was extended and submitted for publication; a model for 1980 to 1983 combining DE-2 with Magsat and surface data was published; and the field modeling data set was cleaned up and reorganized. The usefulness of data from other satellites (DE-1, Active Mesospheric Particle Tracer Explorer (AMPTE)) is being

investigated. With ESIS/National Oceanic and Atmospheric Administration (NOAA), reduction of the marine magnetic data set for use in main field modeling is under way. An effort has begun to acquire marine data not now available to Environmental Data and Information Service (EDIS). A spline representation for secular variation has been incorporated in the coming year. Models of the fluid velocity at the top of the core have been used to study steady motional induction and steady flux diffusion and how the two are combined. These studies will continue, as will studies of coupling between core and mantle. Models of external fields will be determined so as to match existing data and then utilized to predict the nature of the fields at presently unexplored altitudes at which future missions may fly.

W90-70570 **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: (1) develop a model of the earth's gravity field based upon satellite tracking and altimetry and surface gravity data using the computed geopotential model, the interim field, as the a priori model at the beginning of the Topography Experiment (TOPEX) and other gravity missions; (2) develop state-of-the-art geodynamic software systems; (3) perform research through the interpretation of geopotential signals; (4) evaluate flight concepts for a cryogenic gravity gradiometer using the Spartan configuration; (5) 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 (6) 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 on 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.

W90-70571 **676-59-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAVITY FIELD MISSION STUDIES
D. Sonnabend 818-354-7593

This RTOP began with an effort to develop magnetic eddy current isolation systems for sensitive instruments, particularly gravity gradiometers. The technique provides either active vibration isolation or intermittent drag free operation of the payload instrument, with minimum impact on carrier vehicle 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. Single axis, closed loop control by this technique has been demonstrated in the laboratory; and future work on optimal control laws, and better modeling of the magnetic interaction, are intended. Recognizing that the software needs of gradiometer missions are well behind the hardware, the emphasis of the RTOP has been shifted. The new work includes remote identification of the gradient and instrument attitude by dynamic estimation. Software for the latter is now available, and will be extended toward determining mission quality - the accuracy with which the global gravity potential can be derived.

W90-70572 **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 GPS-based measurement system for sub-centimeter geodesy is being developed and deployed in California, Mexico, the Caribbean, and South and Central America. The broad objective is to achieve baseline accuracies of 1 cm or better in the local vertical and a few millimeters 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. A third objective is to obtain, by deployment in regions not easily accessible to VLBI and SLR systems and through network densification, valuable crustal deformation rates that are complementary to those obtained from other 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. Plans for new campaigns in the SE Pacific and Tibet/western China are underway. System development will continue to build on the successful campaigns and technology development conducted in the FY-85 to FY-89 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 1/2 cm in the horizontal components. Improved field equipment, including a ruggedized Rogue GPS Receiver, antenna/backplane systems for reduced multipath and water vapor radiometers, are being deployed in field experiments. The low-cost, all-digital Turbo-Rogue receiver is under development with first prototypes available in 1991. 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. Geomex I in the Gulf of California was completed in May 1989.

W90-70573 **676-59-31**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS PERMANENT GEODETIC NETWORK
W. Melbourne 818-354-9627
(676-59-31; 676-59-45)

The objectives of this RTOP are: (1) to deploy and operate a pilot Global Positioning System (GPS) based geodetic network for continuously monitoring regional earth crust deformation with few-millimeter accuracy over distances from tens to hundreds of kilometers; (2) to carry on a program of technology development to improve the performance, simplify the operation, increase the spatial density, extend the range of applications, and reduce the cost of continuous GPS monitoring; and (3) to analyze the scientific data produced by the pilot network with the goal of improving our understanding of crustal strain phenomena on the time scale of hours to months and the implications for crustal rheology and earthquake processes. The approach for the RTOP is to develop and implement a permanent, continuously operating and recording, remotely monitored and controlled network of 12 GPS receivers in southern California. Initially, data will be analyzed with both the JPL-developed Generalized Information Processing SYstem (GIPSY) and the MIT-developed GAMIT software. Key tasks include: (1) development of automated real-time data editing and compression in the receiver; (2) development of integrated communication, command and control; (3) development of efficient software for offline data analysis, management and archiving; (4) deployment of a program of field experiments in southern California; and (5) analysis of the resulting data for the strain periods of interest.

W90-70574 **676-59-32**
Goddard Space Flight Center, Greenbelt, MD.
LASER RANGING DEVELOPMENT STUDY
Thomas W. Zagwodzki 301-286-5199
(692-20-10; 676-10-10)

The long term goal of this RTOP is to develop automated millimeter accuracy satellite laser ranging (SLR) 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. We will investigate potential improvements in ranging system accuracy made possible by recent technological advances in the areas of high-speed timing electronics, photodetectors, and streak cameras. Other research areas include development of acquisition and tracking software and computer algorithms for unmanned operation.

W90-70575 **676-59-33**
Marshall Space Flight Center, Huntsville, AL.
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 10(-4) EOTVOS units (1 EOTVOS unit = 10(-9) sec(-2) 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.

W90-70576 **676-59-44**
Marshall Space Flight Center, Huntsville, AL.
SUPERCONDUCTING GRAVITY GRADIOMETER (SGG) SHUTTLE PAYLOAD STUDY
S. H. Morgan 205-544-0614
(676-59-33)

The objective of this RTOP is to conduct an Accommodation study for a proto-type 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 10(-4) EOTVOS units (1 EOTVOS = 10(-9) sec(-2) 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, the Analytic predictions of the instrument error model, and assess the performance of automated instrument control and data handling/analysis.

W90-70577 **676-59-45**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMARINE GEODETIC SYSTEM DEVELOPMENT
J. A. Scheid 818-354-9627
(676-59-31)

The purpose of this RTOP is to develop a system to monitor plate boundary deformation and plate motion rates at typical plate boundaries which are underwater. The RTOP objectives are therefore to perform the analysis, development, fabrication, and demonstration of a system to determine the location a benchmark on the ocean floor 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 a surface platform is being performed by F. N. Spiess of Scripps Institution of Oceanography. The development of GPS receiver technology for determining the location of an ocean surface platform with respect to the GPS reference frame is being performed at JPL. The underwater portion of the system uses precise travel time difference measurements among a trio of bottom mounted precision transponders. The objectives of this task are to develop and deploy precision transponders and to build the necessary equipment for interrogation of the transponders and reception of their returning signals in an environment free of multipath effects. 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 centimeter 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 of the system.

W90-70578 **676-59-75**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED MAGNETOMETER
E. J. Smith 818-354-2248

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 evaluate the He(3) nuclear precession magnetometer for possible use in space.

W90-70579 **676-59-80**
Goddard Space Flight Center, Greenbelt, MD.
MISSION STUDIES (MAGNOLIA/MAGNETIC FIELD EXPLORER)
G. W. Ousley, Sr. 301-286-8073
(676-59-10)

The objective of this RTOP is to conduct system definition studies for a Magnolia/MFE mission for adapting Magsat designs to Aristoteles, and on Lageos-3 as agreed. 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 CNES that could serve as the basis for a joint cooperative program and magnetometers/booms/star tracker system design for Aristoteles. The French CNES is cooperating with NASA in this study activity which could lead to a joint mission on the Ariane launch vehicle. ESA is assessing the impact of the magnetometer system additions on Aristoteles.

W90-70580 **676-90-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS JOINT APPOINTMENT
Y. Bock 818-354-8840
(676-59-31)

The objective of this RTOP is to provide support to the GPS Continuous Array by setting up the network and analyzing data from the Array. Initiation of a GPS experiment in Indonesia in crustal deformation studies and subsequent data analysis will also occur.

Land Processes Applied Research and Data Analysis

W90-70581 **677-12-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ERS-1 FOREST ECOSYSTEMS STUDIES
J. B. Cimino 818-354-8225
(161-40-02)

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 upon multitemporal observations using truck-mounted scatterometers and some airborne imaging studies. Several questions will be addressed in this study: 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? How are these variations in the backscatter coefficient quantitatively related to specific forest stand and environmental properties via the relevant scattering mechanisms? How can this information be connected to quantities of ecological interest, biomass in particular? 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? If so, what are the most cost and time efficient techniques and how can they best be implemented with orbital sensors such as ESA Remote Sensing Satellite-1 (ERS-1). 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 questions in the pre-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 to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations.

W90-70582 677-20-10
Ames Research Center, Moffett Field, CA.
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.

W90-70583 677-21-00
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL CYCLING RESEARCH ON THE OREGON TRANSECT
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 ecosystems. The approach is to test 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 1990. 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, and to support a workshop in the third year.

W90-70584 677-21-07
Goddard Space Flight Center, Greenbelt, MD.
GIMMS DATA PRESERVATION AND RELEASE
Compton J. Tucker 301-286-7122

Daily global advanced very high resolution radiometer (AVHRR) data sets, covering the time period of July 1987 through December 1987, will be processed and verified by continent. Vegetation Index images will be produced monthly by continent. Raw (i.e., level 1B) AVHRR data and processed data will be converted to optical disc or some other medium. Processed data will be distributed to the scientific community.

W90-70585 677-21-22
Ames Research Center, Moffett Field, CA.
ESTIMATING REGIONAL METHANE FLUX IN HIGH LATITUDE ECOSYSTEMS
L. A. Morrissey 415-694-3617

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 upon 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 upon 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.

W90-70586 677-21-31
Ames Research Center, Moffett Field, CA.
FOREST/CLIMATE INTERACTIONS
D. L. Peterson 415-694-5899
(677-21-35; 199-30-72)

The objectives are to determine the sensitivity of the overall climate system to land-surface mediated energy and water fluxes in the temperate coniferous forest zone. The approach is to interface Forest-BGC, an existing physiologically based model simulating evapotranspiration (ET) and net primary production (NPP) at the watershed level, with the NCAR Community Climate Model (CCM), a global circulation model (GCM). This will be the first instance of using a process-oriented ecosystem model to parameterize the land-surface portion of a GCM, which have historically neglected the land surface vegetation or used empirical parameterizations of it. This will test the extrapolation limits of ecosystem process models in determining the dynamics of ET and NPP at regional scales (1 deg x 1 deg). Variables relating to key processes controlling energy, carbon, and water exchange will be derived from remote sensing, digital terrain, in-place measurement, and soils 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, total biomass, and albedo.

W90-70587 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 RTOP is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and gloal 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 m and 80 m) regional test sites (1 km), continental test areas (4 km 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. Some expected results from this RTOP 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 deforestation, and estimates of forest spatial extent for selected tropical and boreal forests; (5) understanding the coupling of directional reflectance and atmospheric effects; and (6) developing the computer-related software to process large volumes of coarse resolution satellite data and handle multilevel satellite data from the same target.

W90-70588 677-21-35
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL CYCLING IN TERRESTRIAL ECOSYSTEMS
D. L. Peterson 415-694-5899
(199-30-72; 677-21-31)

The objectives are to develop and use theoretical models and empirical studies to derive biochemical information from leaf and canopy spectra; to relate these measurements of ecosystem productivity and nutrient cycling for temperate and tropical gradients and to incorporate these findings into developing ecosystem process models. The approach is to review the state of theoretical models and empirical studies to derive biochemical information from leaf and canopy spectra, especially as this information relates to measurements of ecosystem productivity and nutrient cycling in temperate and tropical forests. To hold a workshop including participants from the fields of ecology, remote sensing, plant physiology and biophysics to critically evaluate past research in this area, formulate new and alternative hypotheses, and suggest approaches for further research.

W90-70589 677-21-36
Goddard Space Flight Center, Greenbelt, MD.
BASIC LAND SYSTEM STUDIES
Forrest G. Hall 301-286-2974
(677-22-29; 677-24-01)

The objective is to provide support for research bearing on land surface climatology. The study results will benefit the International Satellite Land Surface Climatology Program (ISLSCP) in particular, as well as other disciplines and programs that require earth surface reflectances or their biophysical and physical properties. Basic research will be conducted that involves bidirectional reflectance field measurement experiments, and that includes field data acquisitions; field, aircraft, and satellite data analysis; and physically based reflectance model development and validation. The intent is to focus on the analysis of bidirectional spectral reflectance properties that enable improved assessment of earth surface properties that impact local and regional climate. Quantification of the capabilities for assessment of land climatology parameters, including surface albedo, from uni- or multi-directional, spectral band-limited measurements will be accomplished. Procedures for computing shortwave albedo from such measurements from space platform sensors will be developed. New or improved capabilities for the assessment of earth surface properties, such as plant canopy biophysical variables and soil surface type, will be developed.

W90-70590 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 301-286-7840

The objective of this RTOP is to understand the influence of land surface processes on climate change. Sixteen simulations, eight each for summer and winter for the years 1979, 1980, 1981 and 1982, were analyzed in detail. The Simple Biosphere (SiB) model produced far more realistic surface fluxes, rainfall and radiation balance at the top of the atmosphere. Our new and improved parameterization of cumulus convection and fraction and non-precipitating cloudiness also had a significant influence. It is proposed to examine the influence of realistic vegetation changes in desert regions on the global circulation and rainfall. This will be examined in General Circulation Model (GCM) simulation and data assimilation runs. Several vegetation-related sensitivity studies will be carried out to infer the role of vegetation in affecting weather and climate. The role of evapotranspiration and surface roughness of vegetation is likely to have the dominating influence. Soil moisture anomaly studies with the SiB model are likely to yield a more realistic and significantly different response as compared to the earlier studies at GLA. Extensive use of the SiB model for these studies is expected to lead to a better understanding of the role of vegetation on general circulation and rainfall over the world.

W90-70591 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.

W90-70592 677-22-27
Goddard Space Flight Center, Greenbelt, MD.
HYDROLOGIC INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
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; and (3) to examine the spatial integration of these estimated variables and parameters using remotely sensed data. Remotely-sensed data to determine these variables will be obtained from field, aircraft and spaceborne measurements. 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. The Special Sensor Microwave Imager (SSM/I) data

set for snow volume will be compared with Scanning Multichannel Microwave Radiometer (SMMR) data set. Surface model for decadal global hydrological cycle model will be tested. Results from an experiment conducted in Botswana will test energy balance modelling in tropical savanna grasslands. Soil hydraulic properties will be estimated with remotely sensed data.

W90-70593 **677-22-28**
Goddard Space Flight Center, Greenbelt, MD.
WATER RESOURCES CYCLING (ISLSCP)
R. J. Gurney 301-286-5480
(677-22-27)

The objective of this RTOP,the International Satellite Cloud Climatology Project (ISLSCP), is 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. The approach will be to analyze existing satellite data, e.g., National Oceanic and Atmospheric Administration/Advanced Very High Resolution Radiometer (NOAA/AVHRR), Nimbus/Scanning Multichannel Microwave Radiometer (SMMR) and LANDSAT/ Multispectral Scanner (MSS) for land surface parameters. 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.

W90-70594 **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 for the first International Satellite Cloud Climatology Project (ISLSCP) 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; and (3) to better understand the use of satellite remote sensing to monitor the components of the surface energy budget. The approach will be to acquire simultaneous satellite, 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. The expected results include: improved weather and climate forecasting; improved understanding of how vegetation modifications effect the global climate; improvement in interpretative techniques and greater confidence in the precision and validity of satellite derived quantities; and a refinement in ground measurement techniques and improvement in experimental methodology to permit the further execution of experiments on a variety of land surfaces.

W90-70595 **677-24-01**
Ames Research Center, Moffett Field, CA.
OPTICAL SCATTERING OF PLANT CANOPIES
J. G. Lawless 415-694-5900

The objective of this project is to determine the relationships between the polarized light scattering characteristics of leaves and plant canopies and the biological properties of the leaf/plant such as plant development stage and leaf relative water content. 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.

W90-70596 **677-24-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL REMOTE SENSING SCIENCE PROGRAM
A. B. Kahle 818-354-7265

The goal of the Remote Sensing Program is to develop basic knowledge of electromagnetic (EM) 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; and (3) incorporate this knowledge in discipline-specific studies through communication and collaboration with other Land Processes investigators. Specific tasks include application of heterogeneous scene models to retrieval of land surface and atmospheric properties, radar scattering from forested areas, and models of directional emission from rough surfaces.

W90-70597 **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. 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. 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.

W90-70598 **677-24-02**
Goddard Space Flight Center, Greenbelt, MD.
LEAF BIDIRECTIONAL SCATTERING AND ABSORPTION STUDIES
Thomas W. Brakke 301-286-3851
(677-24-01)

The objective of this RTOP is to estimate individual leaf 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. A data base will be developed for selected deciduous tree species using a laboratory goniometer with illumination provided by visible and near infrared laser sources. The scattered light will be measured at multiple view angles for both nadir and off-nadir illumination directions. Polarization effects will be considered. 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. 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.

W90-70599 **677-29-12**
Goddard Space Flight Center, Greenbelt, MD.
TOPOGRAPHY FROM SEASAT AND GEOSAT OVERLAND ALTIMETRY
Herbert Frey 301-286-5450

The objectives of this RTOP are: determine the accuracy and quality of topographic data that can be derived from Specialized Experimental Applications Satellite (SEASAT) and GEOSAT overland altimetry on a global basis; develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and produce uniform, high quality global topographic data in both gridded and profile form and make these available to the scientific community for both global and regional studies. The approach will be to: evaluate the extent of the attitude and re-acquisition problems experienced by GEOSAT in terms of amount of useable overland data recoverable from this mission; retrack selected portions of the GEOSAT overland altimetry data and merge this with the data already produced by us from the SEASAT mission; produce global and continental scale topographic maps after removal of geoid and correction for slope-induced error; 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; produce contour maps derived from the satellite altimetry maps for each continent along with maps showing the quality of the mean values derived for each grid point; and make these maps and the original data available to the scientific community through a user-oriented data system such as Pilot Land Data System (PLDS). Expected results are a global topographic data set of uniform, high quality derived from a single type of measurement, reference to a common base with knowledge of both the intrinsic accuracy and its variability with region.

W90-70600 **677-41-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTISPECTRAL ANALYSIS OF SEDIMENTARY BASINS
H. Lang 818-354-3440

The primary objectives are to: (1) refine geological understanding of the formation and evolution of the Wind River/Bighorn Basin area, Wyoming and Guerrero/Morelos Basin area, Mexico; (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) integrate lithologic and structural information from remotely sensed data with that obtained from conventional field mapping, borehole and geophysical data; and (4) use results to test geophysical crustal models and models of plate interaction. A collaborative effort by investigators from Geology and Cartographic Groups at JPL and 10 other organizations will acquire and coregister remote sensing data from orbital and airborne systems and conventional data to: (1) define stratigraphic units, map facies and determine their physical and mineralogical attributes in order to infer environments of deposition and paleogeography; and (2) 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 FY-90, we will implement research recommendations from the FY-89 workshop that: (1) identified critical gaps in current understanding of basin evolution and topical geological problems in the study areas, and (2) assessed the utility of geological information derived from remote sensing for addressing these problems.

W90-70601 **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 continental 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 to: (1) determine the extended spectral signatures of desert piedmont surfaces of different ages using multisensor remote sensing data in areas where these surfaces have been dated; (2) 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) 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) develop a regional chronology of climate change based on the maps and ages. The first two years of this study have concentrated 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 have included Death Valley, Owens Valley, and Cima volcanic field. Efforts will be concentrated this year on additional sites, listed in the attached Flight Request, at which the same processes dominate and on the use of the signatures to correlate and map geomorphic surfaces throughout Great Basin. Measurements of microwave penetration in desert soils will also be acquired.

W90-70602 **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 Samail 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. This will be done using Thematic Mapping (TM) images, laboratory analyses of samples, and field work. In Tibet Thematic Mapper and Speed POsition and Track (SPOT) data will be used with field work and dating to determine the tectonic history of the Karakorum fault, one of the major strike-slip faults resulting from the collision of India with Asia. It is a major unknown piece in Asian tectonics, both for current activity, and historical dextral escape of Tibet. This information will be synthesized into tectonic models for deformation of Tibet. The Ironhill, Colorado carbonatite will be studied using TIMS data to map mineralogical facies, and integrate with ongoing USGS AVIRIS studies, in collaboration with Dr. Rowan, USGS, Reston. This study will examine carbonatite emplacement in relation to tectonic environment in an intra-cratonic setting.

W90-70603 **677-43-09**
Goddard Space Flight Center, Greenbelt, MD.
ARCHEAN SUBPROVINCE BOUNDARIES
Robin Bell 301-286-3621

The objectives of this RTOP are: to document

association/interactions between vegetation assemblage and lithology in the southern Boreal forest; to better understand at what spatial scale rock-soil relationships have the strongest manifestation, specifically with respect to remote sensing of lithology in vegetated areas; to better understand the spatial and chemical distribution of certain rock types associated with a major fault system, specifically with respect to geobotanical remote sensing of such; and to better understand the nature of the fault system boundary between two Archaen subprovinces. Field data on vegetation, soil and lithologic distribution and available mapped information will be combined with satellite data to enable assessment of the degree to which spectral data can be used for lithologic mapping. Petrologic and geochemical laboratory analyses will yield constraints on historical interpretations of lithologic distribution. Aerial photography will be used as a supplement to field data collection in specific areas to verify predicted vegetation-rock type associations. Expected results include: quantification of the degree to which rock type might be considered a controller of vegetation in the southern Boreal-St. Lawrence forest; contribution to the understanding of Archaen continental evolution; and predictions of the response of vegetation in the Boreal forest to soil heavy metal enrichment (i.e., ultramafic rocks).

W90-70604 **677-43-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING STUDY OF THE TECTONICS OF THE SOUTHWEST
R. G. Blom 818-354-4681

The objectives of this work ar to apply state of the art remote sensing data and methods 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. The accommodation of recent 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. Previous work on extensional tectonics 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 a regional synthesis. Our efforts will concentrate 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 Speed POsition and Track (SPOT) images, and Specialized Experimental Applications Satellite (SEASAT) radar data have proven most useful. Advanced remote sensing data from Advanced Very High Resolution Radiometer (AVIRIS) and the DC-8 Synthetic Aperture Radar (SAR) are also requested herein for particular study areas.

W90-70605 **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 erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a GSFC aircraft laser altimeter (1 to 10 m footprints, approximately 0.5 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 for selected targets including youthful volcanics (CIMA flows, Death Valley) and coastal erosion features (Delmarva barrier islands and Nauset/Monomoy 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 FY-90 activities will emphasize Cape Cod coastal erosion by means of establishing a database of transverse beach profiles, and the support of the GRSFE Project.

W90-70606 **677-43-25**
Goddard Space Flight Center, Greenbelt, MD.
STUDIES OF VOLCANIC SO2
Louis S. Walter 301-286-2538

The goals are to expand understanding of volcanic processes and the geochemistry of sulfur and to investigate SO2 emissions as precursors for predicting violent eruptions. The objectives of this RTOP 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 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; estimate global volcanic emission of SO2 and rate of deposition on land and in the oceans; and define future sensor/system requirements based on observational characteristics determined in this study.

W90-70607 **677-43-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF ACTIVE AND RECENTLY ACTIVE VOLCANIC FEATURES
D. C. Pieri 818-354-6299

Under this RTOP we plan to continue acquisition and analyses of multispectral data on active and recently emplaced volcanic features and related aerosol and gas emissions across a variety of wavelengths from UV through short and long wavelength thermal infrared (e.g., UVS, AVIRIS, AIS, NS001, TIMS, TM, SPOT, and Inframetrics 525). In particular, we are investigating the relationship between remotely acquired data (e.g., TIMS, 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 and constituent flows including analyses of thermal data from active lava flows, and morphological and spectral analyses of the Carizozo Malpais in New Mexico, Mount St. Helens, and the Kliuchevskaya Shield in Central Kamchatka. We are drawing on data and techniques already acquired and proven by the JPL Geology Group and on ongoing work and accomplishments by the JPL Volcanology Subgroup in theoretical and applied volcanology. We are proceeding to implement these techniques from satellites and aircraft to address basic volcanological problems (e.g., thermal budgets of active lava flows), and look forward to extend insights toward global habitability and societal risk concerns, particularly with regard to high-energy explosive eruptions.

W90-70608 **677-43-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MISSION STUDY FOR AN ORBITING VOLCANO OBSERVATORY (OVO)
D. C. Pieri 818-354-6299

The objective of this RTOP is to study the science rationale and mission design/optimization for a Scout or Pegasus-class (Earthprobe) mission. This mission's primary objective will be an

intense study of the earth's volcanoes form orbit, in order to develop comprehensive time-series data bases for a variety of volcanic phenomena at a variety of wavelengths. Such a mission could provide valuable scientific and instrument optimization data and experience which could be usefully brought to bear for both the Eos Volcanology Interdisciplinary Science investigations and for similar investigations envisioned for the Earth Science Geostationary Platform. The focus of such a mission would be comprehensive and time-systematic monitoring of a well-posed set of known active volcanoes. Of particular interest, will be volcanoes for which ground volcanological observatories have been established (e.g., Hawaii, Mt. Etna, Kamchatka, St. Augustine). It would be desirable to be able to make such observations in a spectral range from UV through near and thermal IR with a spatial resolution of order 10 to 50 meters. Instrumentation for such a mission could easily build on space-qualified imagers available today at JPL.

W90-70609 **677-43-26**
John C. Stennis Space Center, Bay Saint Louis, MS.
DELTAIC SEDIMENTATION AND GEOMORPHIC EVOLUTION OF A DEVELOPING RIVER DELTA SYSTEM
Douglas L. Rickman 601-688-1920

The primary objective of this project is to conduct a multi-disciplinary investigation of the earliest stage in the development of a major Mississippi River delta lobe. The new delta lobe is just the visible manifestation or result of a complex set of dynamic processes, which affect the entire Atchafalaya-Chenier Plain Sedimentary System. The proposed research is an attempt to understand those processes. The research requires a combination of marine geological, coastal oceanographic/marine meteorological, and remote sensing. The combination will provide the sedimentary architecture of the system, the processes responsible for that architecture, and establish procedures for the use of remote sensing systems in regional environmental monitoring and management.

W90-70610 **677-43-26**
Goddard Space Flight Center, Greenbelt, MD.
COASTAL PROCESSING - NILE DELTA
Patrick T. Taylor 301-286-5412

The objective is to employ remotely sensed satellite images (LANDSAT MSS, TM and SPOT) to chart, in detail, the nature of the coastal sedimentation budget for portions of the Nile Delta. These changes result from coastal erosion, sediment (or lack of) from the Nile River and coastal subsidence. This subsidence results from sediment loading and increasing sea level. The approach will include: inventory of all remote image data bases (14 years of MSS, 4 years TM, 3 years SPOT) to establish chronology of coast line change, a precise registration of data to best available geodetic control; differencing consecutive images to establish precise yearly changes; and establishing 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.

W90-70611 **677-43-27**
Goddard Space Flight Center, Greenbelt, MD.
EAST AFRICAN RIFT TECTONICS AND VOLCANICS
James R. Heirtzler 301-286-5213

The objective of this RTOP is to determine the relationship of recent volcanic activity to major tectonic features of the entire East African Rift. Since tectonic and volcanic activity are the major factors shaping the Earth's crustal and surface features in that area we expect to have a better understanding of the development of the East African Rift during the Quarternary and Recent geological eras. We expect to gain insight on the transformations that oceanic rifts undergo coming onto continental crust. Various geophysical data sets, including topographic, magnetic, volcanic, seismic and heatflow, will continue to be put in compatible digital formats. Geological maps will be collected. Remote sensing tapes will be inventoried and selective images processed and printed. Vegetation which may influence geological interpretations will be identified. Mosaics will be made of images which contain geologic information and which are permitted within budgetary constraints.

W90-70612 **677-43-27**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF REMOTE SENSING IMAGERY TO TECTONIC PROBLEMS IN NORTHEAST AFRICA AND THE RED SEA REGION
T. H. Dixon 818-354-4977

The objectives of this RTOP are to: (1) 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) evaluate utility of various remote sensing data sets in the region for attacking the above problems. The approach of this RTOP is 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.

W90-70613 **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, Synthetic Aperture Radar (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.

W90-70614 **677-45-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EVOLUTION OF VOLCANIC TERRAINS
A. B. Kahle 718-354-7265
(677-80-23; 677-43-25)

The long range goals of this project are two-fold: (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. 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 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 extend the work to poorly known volcanic areas globally. One such area is the TransMexican Volcanic Belt where we are collaborating with Dr. Michael Sheridan and students from Arizona State University. Others in future years may include Icelandic, Alaskan, or So. American volcanic centers as opportunities and scientific rationale are identified.

W90-70615 **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: (1) 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 (2) to develop and improve anomaly reduction and analysis methods for use with the Magsat data and future near-earth magnetometer missions (e.g., Aristoteles or Tether). Using the methods and techniques previously developed to reduce and interpret Magsat data we are 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 or Thermoremanence Magnetization (TRM) or Viscous Remanence Magnetization (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. We are using other data types to aid in these regional interpretations; more recently, topographic and LANDSAT images. These topographic data sets are processed to allow us to compare long-wavelength components of both data types.

W90-70616 **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 the 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 discovered. An additional objective is to study the mission concepts for adding a magnetometer experiment to the Aristoteles mission. 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; (4) developing and evaluating analyses techniques; and (5) conduct a Phase A study for a magnetometer experiment on Aristoteles.

W90-70617 **677-45-09**

Goddard Space Flight Center, Greenbelt, MD.

MAGNETIC PROPERTIES OF CRUSTAL MATERIALS

P. 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. Spectral data will be acquired in the visible/near IR and thermal IR regions.

W90-70618 **677-46-02**

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

CHARACTERIZATION OF GEOLOGIC SURFACES USING MULTIPARAMETER 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 Earth Science from Space should be to determine the global distribution of continental rocks. Any initiative 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 Synthetic Aperture Radar (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 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; and (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.

W90-70619 **677-80-06**

Ames Research Center, Moffett Field, CA.

TERRESTRIAL REMOTE SENSING SUPPORT

P. A. Matson 415-694-6884

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) and will contribute toward development of new remote sensing facilities for use by incoming senior civil servant personnel. 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 and for one-time additions of specific state-of-the-art equipment. Support for aircraft use planning will be provided by providing staff support necessary for regular meetings of the Land Aircraft Science Management Operations Working Group (LASMOWG).

W90-70620 **677-80-09**

Goddard Space Flight Center, Greenbelt, MD.

LANDSAT DATA

Locke M. Stuart, Jr. 301-286-5411

The objective of this RTOP is 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, expanded to encompass other earth resources data, and that the Browse Facility cooperate with

the Pilot Land Data System (PLDS) in establishing a university LANDSAT data exchange program. While the LANDSAT Final Results Workshop was held in September 1988, investigators will be permitted use of processing and analysis facilities until contract closeout, which may be as late as the end of December 1989. 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 NASA investigators.

W90-70621 **677-80-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOLOGY MAGNETOMETER STUDY
T. H. Dixon 818-354-4977

The objective of this RTOP is to: contribute to a better understanding of crustal structure through spaceborne magnetometer measurements; provide general program support for potential NASA missions to study crustal magnetic fields; and perform Phase A studies for a potential NASA contribution to ESA's Aristoteles mission, a low earth orbiting gravity gradiometer. The NASA contribution could include scalar and vector magnetometers, a high precision Global Positioning System (GPS) tracking system and supplemental ground tracking and data receiving stations.

W90-70622 **677-80-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAND PROCESSES PROGRAM SUPPORT
C. Elachi 818-354-2317

The objective of this RTOP is to provide support to the Land Processes Branch, Earth Science and Applications Division. A JPL detailee will be assigned to NASA Headquarters to provide assistance in the development and monitoring of the NASA Land Processes programs. In addition, support will be provided to the NASA Land Processes Branch in the study, evaluation, definition, and development of remote sensing techniques to study land processes phenomena as they shape our biologic and geologic environment. The approach will consist of two elements: (1) invite distinguished visiting scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists; and (2) support new ideas and approaches to the level of allowing the submission of viable proposals for peer review.

W90-70623 **677-80-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGE PROCESSING CAPABILITY UPGRADE
S. Schultz 818-354-6363

The objective of this work is to upgrade the facilities available to the geology group for image processing and for analysis of field samples. The current operational image processing computer system consists of the group's VAX 11/750 computer, 1.2 gigabytes of disk storage, one tri-density high speed tape drive, one medium density tape drive, and a color interactive image processing workstation. It uses the TAE/VICAR2 image analysis software system. Access to the VAX 11/750 may be accomplished via 8 directly connected terminals, 3 telephone line modems, ILAN (the JPL local network), and ARPANET. Upgrades to the geology group's facilities that are required this year include the purchase of a computer of larger capabilities, in addition to maintenance services for the group's existing computer, until it is phased out. The approach to be taken consists of the purchase of a computer that uses the UNIX operating system. One candidate system of the proposed scope would be a SUN-4/3xx system. The disks, tape drives, image display system, terminals, networking hardware, and, where feasible, all other peripherals to the VAX 11/750 would be moved to the new system. Maintenance services for the VAX 11/750 will continue until the new system is in place.

W90-70624 **677-80-23**
John C. Stennis Space Center, Bay Saint Louis, MS.
TIMS OPERATIONS
M. Tilton 601-688-1939
(677-48-05)

The objectives of this RTOP are to support Code E by providing for the necessary repair, maintenance, calibration, spares, and field support of the Thermal Infrared Multispectral Scanner System (TIMS) and to provide geologic applications data acquisition missions for JPL. This will be accomplished through: (1) periodic maintenance and calibration of the TIMS System; (2) minor repairs and refurbishment to the System to avoid degradation of performance; (3) support in the form of personnel to perform field diagnostics and field repair (when appropriate); (4) spares for the TIMS System; and (5) accomplishing Data Acquisition missions.

W90-70625 **677-80-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THERMAL IR OPERATIONS
A. B. Kahle 818-354-7265

The overall objective is to support and promote thermal infrared remote sensing through the use of the Thermal Infrared Multispectral Scanner (TIMS) and other associated instruments. The tasks include: (1) overall management and science support; (2) mission planning and coordination; (3) data processing and analysis support; (4) instrument maintenance, performance, evaluation, operations, calibration, and documentation; (5) the completion of the airborne Thermal Infrared Imaging Spectrometer (TIIS); and (6) the completion of an on-lab calibration facility for the TIMS and TIIS instruments.

W90-70626 **677-80-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGING SPECTROMETER OPERATIONS
D. Vane 818-354-9136

In overview, the 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. AVIRIS acquires spectral radiance image in 210 unique contiguous 10 nm channels ranging from 400 to 2450 nm in the electromagnetic spectrum. The specific objectives covered by the tasks under this RTOP include: (1) overall management of AVIRIS operations; (2) mission planning and investigator coordination; (3) sensor operations and maintenance; (4) instrument spectral, radiometric, geometric, and signal to noise calibration; (5) archival and retrieval processing of high density tapes; (6) timely distribution of data products to investigators; (7) support to investigators visiting JPL to use the AVIRIS computing facility for data analysis; (8) development of the Spectral Analysis Manager II (SPAM II) to interface with the LOWTRAN 7 radiative transfer code; and (9) operation, calibration, and maintenance of the Portable Instantaneous Display and Analysis Spectrometer (PIDAS) for NASA investigators. 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 laboratory includes the equipment and facilities purchased or developed under system development funding. SPAM II development will be undertaken by a SPAM programming engineer, who is presently familiar with SPAM I.

W90-70627 **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS
W. E. Brown 818-354-2110

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parametrizing surface physical characteristics. In addition, this work serves to develop engineering methods that can and are used to fabricate spacecraft Synthetic Aperture Radar

(SAR). In FY-90, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and JPL. Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SARs. The plan is to reduce the data from 200 scenes to three frequency imagery, each with four polarizations, (12 images). System evaluation will be carried out to assess the validity of the data. Calibration systems will be designed and developed, particularly for P-band (410 to 450 MHz). The development of a new ground data processing facility will be initiated; the new system will allow improvements to be made in data quality and increase the processing throughput. The task to reduce the size and increase in performance of the radar will be initiated. The goal is to reduce the number of racks in the crew compartment from 10 to 3, the remainder of the equipment will be located in the aft baggage compartment. In FY-91, the AIRSAR equipment repackaging and the new processing facility will be completed and maintenance and operation of the AIRSAR will continue as in FY-90.

W90-70628 **677-80-28**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATION
W. E. Brown 818-354-4631

The purpose of this task is to enable a joint NASA/DARPA activity in the development and operation of the Airborne Synthetic Aperture Radar (AIRSAR) system to support research and advanced development tasks for each agency. The primary objective of the overall RTOP is to maintain and operate the airborne SAR in science experiments in FY-90, conduct studies and implementation of system upgrades, and to generate data products from the data acquired in FY-89 and FY-90. The present RTOP is an expansion of the task elements associated with the overall RTOP for DARPA-related activities. The activities will include the development of a data processing system that will generate high resolution images utilizing the 40 MHz radar signal. We will also process a significant fraction of the imagery acquired during the Loch Linnhe experiment in summer of 1989 for distribution to the DARPA investigators and for scientific analysis at JPL. We will conduct feasibility studies for, and, where feasible, actual implementation of system upgrades that are required for future experiments, taking into account funding, aircraft and schedule constraints. We will also participate in planning meetings for DARPA in order to ensure that the experiments planned for FY-90 are compatible with the overall aircraft schedule and science experiment plan.

W90-70629 **677-80-80**
Goddard Space Flight Center, Greenbelt, MD.
PROGRAM DEVELOPMENT GODDARD SPACE FLIGHT CENTER (GSFC)
Locke M. Stuart, Jr. 301-286-5411
(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) improve laser altimetry techniques; (4) provide viable simulation instrumentation for Moderate Resolution Imaging Spectrometer (MODIS-T) and High Resolution Imaging Spectrometer (HIRIS); (5) operations and management of computer facilities; (6) characterization of Thematic Mapper performance and other optical sensors; (7) SPOT calibration studies; (8) advanced computing facility support; and (9) the advancement of knowledge of the usefulness of reflected polarization parameters. The principal results expected in the next year are: calibration and operations of synthetic aperture L-band radiometer; continued evaluation of Pilot Land Data System (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, and increased knowledge of the value of returned polarized signatures.

W90-70630 **677-90-20**
John C. Stennis Space Center, Bay Saint Louis, MS.
UNIVERSITIES SPACE RESEARCH ASSOCIATION (USRA) VISITING SCIENTIST PROGRAM IN LAND-SEA INTERFACE RESEARCH
Armond T. Joyce 601-688-3830

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 (SSC) existing capabilities in this area, this proposal outlines the creation of a research associates program at the Science and Technology Laboratory (STL). In order to build upon the strengths of existing STL research and to take advantage of the STL strategic location, the program would focus on the land-sea interface. The goal of the program is to create a significant recognized center for multidisciplinary research in land-sea interface, through the creation of a permanent, albeit rotating, academic presence on site at the STL, along with the sponsorship of topical seminars and symposia.

W90-70631 **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. GSFC responsibility includes the project management and several of the fundamental research tasks. Some approaches to the RTOP will be: 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 conducted in a manner similar to previous years.

Crustal Dynamics

W90-70632 **692-00-00**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS
J. M. Bosworth 301-286-7052
(693-40-00; 693-10-10)

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.

W90-70633 **692-40-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
KINEMATIC STRAIN MODEL
P. Krueger 818-354-6920
(692-60-45)

This RTOP is intended to perform an analysis of the current and accumulating data base of precise positions which have been determined by the space-geodetic techniques of Very-Long-Baseline Interferometry (VLBI), satellite laser ranging (SLR), and Global Positioning System (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. The estimation and modeling techniques will allow for the characterization of tectonic motion on a regional scale of several hundred kilometers (as has been done in work accomplished to date) and also on global scales, spanning multiple tectonic plates.

W90-70634 **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, HVAC, 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 February 1985.

W90-70635 **692-40-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WVR HARDWARE AND SCIENCE REPORT
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. In FY-88 the scope of this task was directed to the problem of the absolute calibration of path delay as determined from WVR measurements of the microwave emission of atmospheric water vapor. This calibration is being carried out in collaboration with Dr. Peter Bender and Steve Walter of the University of Colorado, whose work is supported by separate funding in the Geodynamics Program. 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 further delays in completing the Slant Path Atmospheric Refraction Calibrator (SPARC) at the University of Colorado, the scope of the work performed under last year's RTOP has been reduced from that originally described. However, substantial progress is anticipated in FY-90. We plan to begin a new effort to explore the feasibility of using Microwave Monolithic Integrated Circuit (MMIC) technology for an advanced generation of WVR instruments. Facilities are available at JPL to breadboard and test radiometer circuits in the 20 to 30 GHz range using existing chips, and ultimately to design and fabricate custom circuits. Recent advances in this technology make such an approach appear very promising, and key questions about its suitability for precision microwave radiometry can be answered by breadboarding and testing an MMIC radiometer in the frequency range of a WVR.

W90-70636 **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 J sub 2, J sub 3, J sub 4, 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 coupling, and the non-hydrostatic gravity field shall be examined. The principal objective for this task is to determine how well nutations constrain the core-mantle ellipticity, solid fraction 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 J sub 2 and polar motion constrain viscosity structure.

W90-70637 **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 of the earth, tidal acceleration of the moon, nutations, and the rate and pole of the precession of the earth 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 3 cm accuracy of the ranges being received from all three stations. Principal among these improvements are changes in the tidal displacements of the stations for variable Love numbers, solid body pole tide, and ocean loading. Also intended are upgrades in the software for operational efficiency 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. We have just let it shift in order to allow

for the imposition of the AM0-2 model of plate motion and alignment of our Universal Time (UT1) system with the New Earth Rotation Service (IERS) system. An adjustment of the celestial system with respect to the dynamical equinox remains to be done. The work of this RTOP will also benefit the regular determination of earth rotation and the monitoring of data quality of a companion RTOP (692-60-61).

W90-70638 **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 and visualization 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, kinematic descriptions of the state of crustal deformation in monitored regions are 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. In addition, the incorporation of graphical visualization techniques into the modeling process enables the full scientific interpretation and utilization of the large quantities of numerical data produced thereby.

W90-70639 **692-60-46**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL TECTONIC MOTIONS
R. S. Gross 818-354-4010

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 Infrared Interferometer Spectrometer (IRIS), POLARIS and Crustal Dynamics Program Mark III Very Long Baseline Interferometry (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. 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, 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 2 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.

W90-70640 **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 five tasks. Task 1 (Data Quality Enhancement and Verification) is intended to improve the quality and reliability of estimates of the excitation of changes in the Earth orientation. Estimates (both analysis and forecast fields) of the atmospheric excitation of Earth orientation changes from independent weather forecast centers will be analyzed together with length-of-day data to provide indications of the accuracy of these data. The atmospheric angular momentum (AAM) data from the four centers will then be combined to provide improved estimates of the meteorological excitation of Earth orientation changes. Task 2 (The Atmospheric and Oceanic Excitation of Polar Motion and Nutation) will continue comparisons of geodetic polar motion estimates with meteorological estimates of changes in the equatorial atmospheric angular momentum, comparing and relating variations seen in the polar motion, and with those seen in the UCLA general circulation model of the atmosphere. In addition, it will study diurnal variation in the equatorial AAM. Task 3 (Atmospheric Dynamics and the Excitation of Earth Orientation Changes) intends to improve the understanding of causes of changes in the orientation of the Earth, particularly of changes in the earth's rotation rate, using a combination of modern geodetic data and global meteorological data. A major thrust of this task is to resolve the source mechanisms for the eight-day variation in LOD, whether they be atmospheric, oceanic, or a combination of the two. In addition, the effect of mass distribution changes in the atmosphere will be studied. Task 4 (Numerical Simulations of Atmospheric Angular Momentum Changes) will investigate the intraseasonal oscillation in Earth rotation and in the atmosphere (including the so-called 50 day oscillation) by the use of a general circulation model of the atmosphere to provide insight into Solid Earth-Atmosphere interactions. Task 5 (The Excitation of the Long-Term Decade Fluctuations) 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.

W90-70641 **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 Laser Geodynamic Satellite (LAGEOS) results has revealed variations in the zonal gravitational harmonic coefficient, J2, which constituted 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 of 3 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.

W90-70642 **692-80-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
UNDERWATER GPS BENCHMARKS
F. Spiess 818-354-9072
(676-59-31; 676-59-45)

The seafloor geodesy system currently under development at JPL and Scripps Institute of Oceanography, based on the Global Positioning System (GPS) will soon be able to measure motions of a few centimeters on the ocean floor and tie these into an earth-fixed reference frame. Such motions are expected over the course of a few years across seafloor trenches and mid-ocean ridge and transform fault systems as a product of the large-scale movements of the tectonic plates that cover the earth's surface. Initial interest in applications for the seafloor geodesy system are focused on these major tectonic processes. Superimposed on these large-scale motions, however, are smaller-scale motions due to such processes as stress and strain propagation, thermal heating and cooling, isostatic adjustment, and small-scale convection. These effects are of a smaller scale only in their lateral extent; the motions themselves may be comparable to, or even larger than, the gross tectonic motions. We propose to examine the motions produced by these tectonic processes in a variety of marine geophysical settings, such as fracture zones, transform faults and spreading centers. The first portion of this study will be theoretical. Finite-element computer models of the continental crust incorporating rheological variations and stress/strain propagation will be adapted to effectively model the oceanic crust. Thermal effects will be incorporated, as will the ability to forward model the predicted gravity field, a key observable in the marine environment. The finite element model will be initialized using results of recent deep-sea surveys and the latest surface-ship and satellite gravity studies. We will use the model to evaluate those relative motions due to the above mentioned tectonic processes that may be observable by the seafloor geodesy system. The second portion of this RTOP will focus on performing an actual experiment based on the results of the above study. There are a number of scientific and logistical obstacles which need to be overcome, due, in part, to the great oceanic depths at which fracture zones and transform faults are usually found, and the need to separate large-scale plate motions from the more subtle local and regional motions. We will investigate and evaluate the most practical and fruitful seafloor sites for this particular experiment. The actual conduct of this experiment will require the joint involvement of an institution with substantial ocean-going geophysical experience; contact with such an organization and the obtaining of additional funds for shipboard research is now underway. We will take advantage of the ongoing RTOP collaboration of JPL (L. Young) with Scripps Institute of Oceanography (F. Spiess) to develop the seafloor geodetic system and to provide initial system testing off the Southern California coast.

W90-70643 **692-92-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SEA LEVEL CHANGES
R. S. Gross 818-354-4010

The fundamental objectives of this study are: (1) to determine improved estimates for the eustatic changes in sea level; and (2) to estimate secular and other long period changes in polar ice volume. Our approach is of an interdisciplinary nature and will include the analysis of several geodetic, oceanographic, and meteorological data sets, together with extensive numerical modeling efforts. The various data types include surface temperature and monthly tide gauge data, earth's rotation and gravitational field data, space geodetic observations of vertical crustal motion, and satellite altimeter results. Improved estimates for the global rise in sea level will be obtained by analyzing tide gauge data directly, and by observing and subsequently interpreting the effects of a changing sea level on the earth's rotation and gravitational field. In turn, the earth's rotation and gravitational field data results, as well as observations of vertical crustal motions, will be used to derive new constraints in the post-glacial rebound modeling effort. Better estimates of the amount of melting of the Antarctic and Greenland ice caps, and of the continental glaciers will be computed by recovering and then by interpreting the expected effect of this melting upon the earth's rotation and gravitational field. Tide gauge data will be used to directly estimate the global change in the level of the seas. Data obtained from space-geodetic observations of the earth's rotation and gravitational field will be used to indirectly estimate the sea level change through its effect of changing the earth's mass distribution and hence rotation and gravitational field. The space-geodetic data will also be used to derive new constraints for use in the post-glacial rebound modeling effort. A decrease in the total volume of the polar ice caps or of the continental glaciers could be an indication of an enhanced greenhouse effect. We will search for the effects of changes in ice volume using, primarily, the time-dependent gravitational field coefficients. We will supplement those data with earth rotation information.

Laser Network Operations

W90-70644 **693-70-00**
Goddard Space Flight Center, Greenbelt, MD.
LAGEOS 2 (INTERNATIONAL COOPERATIVE PROJECT)
G. W. Ousley, Sr. 301-286-8073

The objective of this RTOP is to provide a cooperative U.S./Italian spacecraft to be used by the Crustal Dynamics Project (A NASA (Laser Geodynamic Satellite (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

W90-70645 **879-11-38**
Goddard Space Flight Center, Greenbelt, MD.
SOUNDING ROCKET EXPERIMENTS
Roger J. Thomas 301-286-7921

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.

OFFICE OF SPACE OPERATIONS

Advanced Systems

W90-70646 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 in NASA. The technology to be studied includes software development methodologies, development tools, measures and models, the Ada language, 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 tools, methodologies, and models may be acquired, developed, applied, and studied in an actual software production environment. This laboratory, called the Software Engineering Laboratory (SEL), first of all identifies technologies of potential benefit, then 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. Each of the projects is then carefully studied to determine the impact and to further identify refinements or additional technologies that could positively impact NASA software and would be directed at addressing specific NASA software shortcomings.

W90-70647 310-10-26
Goddard Space Flight Center, Greenbelt, MD.
FLIGHT DYNAMICS TECHNOLOGY
M. V. Seldewitz 301-286-7631

The objective of this RTOP is to develop, evaluate, and demonstrate new technology for flight dynamics in the TDRSS and 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 approach of this RTOP is to: (1) develop, demonstrate, and evaluate one-way Doppler tracking via TDRSS multiple access return link using an ultrastable oscillator onboard a user spacecraft (COBE Flight Experiment); (2) study orbit determination using sequential filtering (Sequential Orbit Determination); (3) study means of specifying generalized flight dynamics software (Generalized Systems study); and (4) study and evaluate advanced, generic attitude determination methods (Advanced Attitude Determination).

W90-70648 310-10-60
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROMETRIC TECHNOLOGY DEVELOPMENT
C. D. Edwards 818-354-4408
(310-10-61; 310-10-62; 310-10-63; 310-20-67)

The objective of RTOP 60 is to design and demonstrate improved techniques of astrometric data acquisition and analysis as used by the 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. Deep space tracking is currently limited by uncertainties in the angular components of spacecraft position and velocity. Thus a major thrust of this RTOP involves refining methods of angular spacecraft navigation using various astrometric techniques, primarily Very Long Baseline Interferometry (VLBI). Based on analysis of VLBI data, 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 toward 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 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. Short baseline intracomplex interferometry experiments are currently being performed to quantify the navigation potential of CEI. Development of a realtime correlator at Goldstone over the next year will demonstrate reduced navigation turnaround time while improving experimental reliability by providing on-line verification. Evaluation of optical tracking techniques will determine the potential of optical tracking to meet or exceed current radio metric capabilities, for application on future laser-equipped spacecraft. In addition to characterizing the performance of ground or space-based devices, problems associated with establishing a stable optical reference frame will be addressed.

W90-70649 310-10-61
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS-BASED DSN CALIBRATION SYSTEM
Stephen M. Lichten 818-354-1614
(310-10-60; 310-10-63; 676-59-31)

The objective of this RTOP is development of an integrated Deep Space Network (DSN) calibration system based on high-accuracy tracking of Global Positioning System (GPS) satellites. It will provide continuous calibration of limiting error sources for missions which rely on the DSN radio antennas for Doppler, ranging, and VLBI data collection. These calibrations will include: sub-cm zenith tropospheric delay accuracy; cm-level monitoring of earth orientation with resolution of better than one day; sub-nanosec DSN intersite clock synchronization; and several-cm geocentric determination of DSN radio antenna coordinates through site ties with collocated GPS receivers. The GPS-based media, clock, earth orientation, and station location parameters, which will provide valuable support during future deep space missions and encounters, are estimated simultaneously with high-accuracy (sub-meter) GPS orbits on a continuous basis. For missions with a medium accuracy navigation requirement, GPS calibrations will provide the DSN with a 50 nanoradian tracking capability using differenced range and/or Doppler, without the need to move the radio antennas off the spacecraft to acquire quasar data. For missions requiring several-nanoradian navigation accuracy where differential spacecraft-quasar VLBI will be necessary, the GPS-based calibrations will contribute timely calibrations of zenith tropospheric delays and earth orientation parameters. The GPS calibrations can be timed to coincide with the deep space radio tracking passses, reducing the demand for DSN antenna time. The GPS-based tracking network will also support 1 to 2 m orbit

determination for high-earth or elliptical orbiters up to geosynchronous altitude, and orbit accuracy at the decimeter level below 6000 km. This RTOP includes: system design, performance analysis; error analysis and parameter estimation software development; study and demonstrations of the use of GPS for DSN calibrations and mission support; and demonstrations of high precision tracking techniques on the GPS satellites and on future earth orbiters. In addition to development of new algorithms, models, and techniques to improve GPS and high-earth orbit accuracy, this RTOP provides ways to apply these new methods to deep space tracking and navigation.

W90-70650 **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; 310-20-64)

The objective of this RTOP is to develop and demonstrate the technology of precise frequency and timing for DSN mission and science support activities. The goal of frequency stability pursued in the RTOP is the demonstration of one part in 10(exp 16) at averaging intervals between 1 and 10(exp 4) seconds in the Goldstone complex, by 1990. The long term goal is the demonstration of parts in 10(exp 17) capability for averaging intervals between 1 second and 10(exp 5) seconds in the 1990's. The work planned is in three areas: (1) the generation of precise frequencies through the demonstration of the trapped mercury ion frequency source, and generation of spectrally pure signals at GHz frequencies with the superconducting maser oscillator, and the sapphire dielectric resonator oscillator; (2) the distribution of frequencies with stability of parts in 10(exp 17) will be demonstrated through the development of fiber-optics systems including electronically stabilized fiber optic cables. A system will be developed to distribute references within the complex and up the antenna, where immunity to temperature and vibration sensitivity is required; and (3) work will be performed to develop the capability for frequency and phase stability characterization and monitoring on an end-to-end basis in a Deep Space Station. This effort will provide near real time information on the status of the stability of precise frequencies generated, distributed, and used throughout a DSS.

W90-70651 **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)

This RTOP encompasses a variety of activities covering the field of space navigation and related areas. The objectives of this RTOP are to: (1) study and determine system-level requirements for new navigation technologies; (2) determine Deep Space Network (DSN) capabilities needed to meet the navigation requirements of future missions; (3) investigate new navigation measurements with the goal of increasing the navigation accuracy achievable with the DSN, while simultaneously reducing the amount of DSN resources needed; and (4) develop a synergistic relationship with advanced mission planning teams that promotes the optimum growth of both DSN and spacecraft navigation capability. In support of its objectives, the RTOP develops data strategies for improving navigation accuracy and enhancing support of navigation-dependent mission activities. Radio tracking applications to difficult new missions, such as low-altitude planetary orbiters and earth-orbiting radio astronomy spacecraft, are investigated. Investigations into improved modeling needed for use of high accuracy radio metric data are conducted. Data strategies to support low-cost missions are developed, and are demonstrated using data from current missions if possible. New navigation technologies are investigated, such as navigation with communication links at optical frequencies. The RTOP also focuses on reducing mission operations costs and increasing throughput and reliability through the automation of radio metric data processing. Examples of projects currently being pursued in this area are: the development of advanced user interfaces in a workstation environment, the implementation of prototype automated event-driven operations, and potential applications for expert system technology.

W90-70652 **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 validating the analytical predictions by means of tests utilizing the actual network hardware developing the capability to predict communications link performance against a mission 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 CLASS to provide a network design and evaluation tool as well as a network user communications system design tool.

W90-70653 **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 Narrowband and Wideband Integrated Digital Services (ISDN and BISDN) Network Technologies; (2) to investigate techniques for interfacing with Open System Interconnection (OSI) networks; and (3) to investigate Local and Metropolitan Area Network (LAN and MAN) technologies. The objectives are being pursued under three tasks. The first task is developing an ISDN/BISDN testbed. The second task is 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 development of a wiring concentrator for a fiber optics area network operating at 100 MBPS for applications to a Center-wide environment. The approach for this RTOP is to focus on three 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 3 or 5 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.

W90-70654 **310-20-39**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED TRACKING TECHNOLOGY
Harley Mann 301-286-4343

The objectives of this RTOP are to design, develop, and demonstrate ATDRS era tracking systems which provide for 25 meter tracking accuracy. It is desired that this system place no load on TDRSS user services, utilize only continental U.S. 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, 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 ATDRSS program as well as stimulate future advanced work in the advanced tracking area if warranted.

W90-70655 **310-20-46**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS
R. P. Hockensmith 301-296-9067

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 in 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 with a high confidence level in the performance capability, cost and required procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

W90-70656 **310-20-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TRANSMITTER SYSTEM 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 transmitter functions, including uplink command capability, emergency commanding, radio science, navigation, and radar astronomy. A 20 kW CW 7.2 GHz transmitter at DSS 13 has been used to demonstrate a complete ground station frequency stability of a few parts in 10(exp 15) when averaged over 1000 seconds. The transmitter has also been used in conjunction with 2 GHz transmitter and receiver subsystems to demonstrate simultaneous noise-free S- and X-band uplink-downlink (four way) operations for future NASA Deep Space use. The design of a state-of-the-art transmitter system from the output of the frequency standard at 100 MHz or higher to the feedhorn output at X- or Ka-band is in progress. 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 NASA anticipated requirements. Techniques will be developed 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. The 70 m antenna at DSS 14 and the new R and D antenna at DSS 13 will be calibrated at 32 GHz.

W90-70657 **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; 310-30-70)

The objectives of this RTOP are to develop electromagnetic, optical, and structural mechanical technology to increase the capabilities of the large antennas in the Deep Space Network for mission support. 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 the 70 m high-efficiency dual-shaped reflector antenna design. Precision bonded panels and microwave holography diagnostic techniques have improved 70 m antenna surface accuracy by a factor of two. Wideband beam waveguide (BWG) optics and an integral ring girder are incorporated in the upcoming DSS 13 antenna. Present objectives are to: (1) evaluate 70 m antenna RF and structural performance for 32 GHz operations and outline an affordable upgrade program; (2) achieve high accuracy and stable RF beam pointing at 32 GHz; and (3) extend BWG antenna technology to 70 m and 34 m antennas. To achieve these objectives, sophisticated computer analysis software appropriate to large high-frequency reflectors is used. Demonstration and tests are planned to verify analytical models and understand critical areas needing cost-effective improvement. The goal is to enable informed decisions on when and how to deploy Ka-band DSN mission suppport.

W90-70658 **310-20-66**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIO SYSTEMS DEVELOPMENT
J. Bautista 818-354-6994
(310-20-65; 310-20-64)

The objectives of this RTOP are to develop and demonstrate low-noise amplifier technology. This technology will lead to ground-based improvements in spacecraft communications and navigation during deep space missions. The improvements sought are increased performance, reduced implementation costs, and increased reliability of navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications link is the gain of the ground-based antenna divided by the system noise temperature (G/T). 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 broadband, high gain low-noise amplifiers at 32 GHz which are compatible with array feed systems. Amplifiers using the principle of microwave amplification by the stimulated emission of radiation (MASERs) and high-electron mobility transistors (HEMTs) are being developed. Also being developed are the analytical tools and measurement systems needed to characterize the associated materials and devices for the design of practical amplifiers.

W90-70659 **310-20-67**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT
James R. Lesh 818-354-2766
(310-10-63; 310-20-60; 506-44-00)

The objective of this RTOP is to develop and demonstrate a reliable and efficient optical communications and tracking capability for use with 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 with 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. 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 definition and planning for a ground-based R and D reception station, formulation and validation of an atmospheric weather model based on existing satellite-collected data, and

establishment of a network of three autonomous visibility monitoring telescopes.

W90-70660 **310-30-69**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMMUNICATIONS DEVELOPMENT ANTENNA
G. E. Wood 818-354-9079

The objective of this RTOP is the development and demonstration of a new antenna and upgraded technical facility for the Goldstone R and D site (i.e., the Venus station, DSS 13). The erection of a new 34-meter antenna is provided under separate FY-88 Construction of Facilities (C of F) authority. The new antenna will enable enhanced technology development and demonstrations of communications and navigational capabilities by the Advanced Systems Program and will serve as a testbed for future DSN implementation. The current 26-m antenna is simply not capable of supporting 32 GHz technology that will be the focus of DSN evolution in the mid-90's. Under this RTOP the station will be provisioned with technical utilities, equipment, and instrumentation to support the new antenna. These will include: a new design subreflector, mount and positioner; antenna pointing interface electronics and computers; X-band Ka-band receiving systems; and system interfaces and cabling. The designs and implementation provided by this RTOP will be validated by performance demonstrations to verify achievement of goals and calibrate the overall system performance of the new antenna at X-band and Ka-band. These demonstrations will be completed during a six-month period following beneficial occupancy of the new facility.

W90-70661 **310-30-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NETWORK SIGNAL PROCESSING
E. Satorius 818-354-3016
(310-20-65; 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. Key objectives for this RTOP are to: (1) achieve Doppler extraction frequency stability of 10(-17); (2) improve telemetry signal-to-noise ratio (SNR) performance relative to existing DSN systems by 1 dB to 3 dB; (3) increase data rate capability from approximately 500 Ksymb/s to 5 Msymb/s in the near term and to 500 Msymb/s in the long term; (4) develop signal processing techniques and algorithms for an array feed in order to improve antenna gain performance at ka-band relative to existing single feed DSN antenna systems by 3 dB to 5 dB; (5) develop a new DSN spectrum surveillance system with sensitivity comparable to the weakest spacecraft signals; (6) develop high speed sampling and digitizing circuits to enable wider bandwidth front-end digital signal processing; and (7) develop custom Very Large Scale Integrated (VLSI) circuits for signal processing whenever cost, speed, complexity size, or reliability dictate; and (8) demonstrate the capability of expert and neural network systems to enhance the performance and operability of the DSN radio and telemetry systems. During FY-90 the main tasks are: (1) to complete integration and testing of a 15 MHz bandwidth advanced receiver including Doppler extraction and telemetry data processing; (2) to plan for a proof-of-concept field demonstration of a Ka-band array feed signal processing system (to be conducted in mid FY-91); (3) to complete the hardware and software integration and testing of a 40 MHz bandwidth, 2 Megachannel digital spectrum analyzer; (4) to complete the development of a high speed sampling and digitizer microcircuit implemented with Gallium Arsenide (GaAs) technology; (5) to complete the development of a custom microcircuit for the advanced receiver and to develop a GaAs, general purpose signal processing chip; and (6) to initiate the development of an expert monitor and control system for the 15 MHz advanced receiver.

W90-70662 **310-30-71**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMMUNICATIONS SYSTEMS RESEARCH
Laif Swanson 818-354-2757
(310-30-70; 310-30-72)

The objective of this RTOP is to develop digital communication systems technology required to meet the needs of DSN supported missions for the 1990's and beyond. We focus on improving space communication capability at low cost. The work planned will involve three areas: (1) coding/decoding (source and error-correcting) and modulation/demodulation techniques for the future will be investigated and demonstrated. We currently support a coding experiment on board Galileo, using a code developed in this RTOP to gain more than 1 dB over the original Galileo code. The longer-term goal involves new research into channel codes and source codes; (2) communication efficiency will be improved for current codes and technology. For example, sometimes changes in convolutional decoding techniques can improve error performance for already existing codes. Much of this work uses previously developed analysis and computer simulations in evaluating proposed and planned changes in hardware or operations; the development of these simulations is an ongoing activity of this RTOP; and (3) coding ideas developed and/or analyzed in this RTOP will be demonstrated.

W90-70663 **310-30-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VITERBI DECODER DEVELOPMENT
J. I. Statman 818-354-2926
(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 DSN by as much as 2 dB. This RTOP is based on previous Advanced Systems RTOP 71 accomplishments, the search for 2 dB coding gain and the 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, (BVD) and test it using DSN facilities, e.g., CTA21. Following successful tests, the BVD will participate in a coding experiment with Galileo in May 1991. In this experiment, Galileo will transmit data encoded with a (15, 1/4) convolutional encoder (that was added to the spacecraft) at rates of 134.4 Kbit/s and 115.2 Kbit/s. The BVD, located within a DSN station's telemetry chain, will decode the received symbol stream in real-time and demonstrate 1.5 dB link improvement compared to (7, 1/2) codes. Following successful completion of this demo, the BVD design for the main Galileo mission will enable 30 percent increase in overall science data return, 100 percent increase in science return during Jupiter arrival and substantial reduction in need for antenna arraying during the tour of the Galilean moons. 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 FY-90 the main tasks are: (1) complete development and fabrication of VLSI chips; (2) develop and fabricate all of BVD hardware; (3) develop BVD operating and diagnostic software; (4) conduct system integration and test; and (5) start preparations for May 1991 demo.

W90-70664 **310-40-37**
Goddard Space Flight Center, Greenbelt, MD.
HUMAN/MACHINE INTERFACE TECHNOLOGY
Walt Truszkowski 301-286-8821

The objectives of this RTOP are to realize developmental and operational improvements in user/machine interfaces and interactions in control center and data processing systems by identifying, researching, and developing state-of-the-art concepts,

models, and tools for supporting the engineering of these interfaces and interactions. The intent is to apply to recent advances in human factors analysis, data and information base management, semantic modeling, and artificial intelligence (AI) to human/machine interface and interaction problems in order to realize the desired improvements. The approach to be followed in realizing the objectives is to provide tools and environments to support the development, evaluation, and use of operational interfaces. The development tool will be a knowledge-based user interface management system. The evaluation will be supported by a tool designed to qualify human performance for on-line activities. Intelligent Tutoring Systems will provide support for the proper use of systems. The RTOP is a system level RTOP supporting TDRSS operations, mission operations, mission support computing, and general systems engineering activities.

W90-70665 **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, 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. First, to study and develop graphic automation techniques for a spacecraft command and control center environment. Graphical displays are being developed for spacecraft controllers which will display data in a more comprehensible form than the current alphanumeric presentation. Second, to assess tools for development and operations of command and control center software systems. This thrust is presently studying the applicability of expert systems in the Multi-Satellite Application Processor System man-machine interface.

W90-70666 **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.

W90-70667 **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 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.

W90-70668 **310-40-49**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED ENVIRONMENTS FOR SOFTWARE AND SYSTEM DEVELOPMENT
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, development, operation, and evolution of MO&DSD data systems. Major subobjectives are: (1) the development of a state-of-the-art performance modeling environment consisting of an integrated set tools and support services which facilitates all phases of the use and reuse of data system simulation; and (2) the definition and phased prototyping 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 MO&DSD. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and TDRSS operations.

W90-70669 **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 non-parallel computer architecture developments applicable to the 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. This RTOP will evaluate alternative approaches to telemetry processing (Level Zero Processing and data handling functions) for parallel and non-parallel computer architecture, study high levels of telemetry processing, and study telemetry processing system architecture requirements for Space Station era data systems. 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 above tasks, benchmarking of critical processing functions will be employed whenever possible.

W90-70670 **310-40-73**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSN DATA PROCESSING AND PRODUCTIVITY
N. R. Kuo 818-354-0475

The objectives of this RTOP are to develop and demonstrate data handling capabilities for the DSN and to develop new software design technologies that will result in improved network capability to meet user needs and reduced development costs. The work that is planned can be divided into two general areas. (1) Real-time system methodology: Major functions in the DSN such as data acquisition, monitor and control, data communication, and data

archiving and retrieval are distributed among subsystem controllers within a network that must respond to real-time events. Emerging Network Management standards offer the opportunity to reduce development costs for real-time monitor and control applications and associated risks through the use of commercially available products. One work unit in this RTOP will address the issue involved in understanding emerging international network standards in regard to their applicability in the DSN. A second work unit will develop the long-term data handling strategy, and algorithms needed to manage the data flow, archiving, and retrieval at the signal processing centers. (2) Software scheduling and design: A growing fraction of the total cost to implement and maintain DSN capabilities is attributable to software. The inability to reliably predict software development schedules jeopardizes mission support and translates into increased costs such as crash efforts mounted in order to meet schedules. One work unit in this RTOP will evaluate development tools that are available with modern computer languages and offer the potential of reducing software life-cycle costs. Another work unit will develop effective software scheduling methods that will enable both program managers and software developers to make accurate assessments of schedules and project plans.

OFFICE OF SPACE FLIGHT

Advanced Programs

W90-70671 **906-12-03**
Marshall Space Flight Center, Huntsville, AL.
STV ADVANCED DEVELOPMENT
John M. Cramer 205-544-7090
(906-12-01; 906-12-02; 946-01-00)

The objective of this RTOP is to conduct advanced development activities for Space Transfer Vehicle (STV) subsystems to verify optimum subsystem selection and/or technology approaches, demonstrate subsystem performance, and reduce development risk. The approach is to design, fabricate, and test subsystem candidates identified in RTOP 906-12-02 using bench tests, breadboards, and where necessary flight tests.

W90-70672 **906-20-03**
Marshall Space Flight Center, Huntsville, AL.
LAUNCH VEHICLE OPERATIONS/TECHNOLOGY/DESIGN MODEL
James W. Steincamp 205-544-0544

The objective is to enhance/develop expert systems and simulations to analyze and trade the operations and technologies required for future launch systems. Operational considerations will be integrated into future launch vehicle designs through total system assessment of operations, design, and technology options.

W90-70673 **906-20-03**
John F. Kennedy Space Center, Cocoa Beach, FL.
KSC APPLIED TECHNOLOGY DEVELOPMENT LABS
George E. Mosakowski 407-867-3494

The objective of this RTOP is to perform advanced development efforts in support ground processing of STS and payload hardware. Advanced development of state-of-the-art enabling technologies will be directed towards decreasing turnaround times, increasing overall efficiencies, and increasing quality and safety.

W90-70674 **906-20-03**
John C. Stennis Space Center, Bay Saint Louis, MS.
FUGITIVE GAS DETECTION SYSTEM
Donald J. Chenevert 601-688-3126

Commercial gas sensor technology does not address the scale or environmental extremes typical of NASA's facilities. The goal of this effort is to develop new technology to present a realistic picture of hazardous gas conditions in liquid propulsion test and launch facilities. Multiple smart sensors will be networked with a system that graphically depicts the location of the sensor and the condition of its environment. A rapid response hydrogen gas sensing device with a response time of less than 15 seconds has recently been developed at SSC. The system is capable of performing in harsh environments, continuously compensating for dynamic conditions, has self diagnostics, and remote digital and analog communications capacity. The specific objective of this project is the incorporation of an improved version of this device with new technology that integrates a network of sensors to a graphic interface. The sensor design will be improved to incorporate surface mount and/or hybrid electronics to increase reliability and reduce size and cost. Software will be developed to support networking and an interface to the improved sensors. A graphically programmable interface will be developed to provide real-time status, trending, concentration contours, expert system shell, and estimation of leak location. An operational test area will be instrumented using the multisensor network to test system performance and evaluate system effectiveness.

W90-70675 **906-20-03**
John C. Stennis Space Center, Bay Saint Louis, MS.
COMBINED SPECTRAL AND VIDEO MONITORING OF SSME PLUMES
Donald J. Chenevert 601-688-3126

The overall objectives of this research are to develop techniques for simultaneous video and spectral emission monitoring of Space Shuttle Main Engine (SSME) plumes during ground testing on aspirated test stands and to develop improved methods for data acquisition and analysis. Special fiber optic probe systems incorporating both coherent and single fiber cables will be designed and fabricated. These probes will penetrate the diffuser area of the test stand to provide optical access to the exhaust plume. Commercially available optical multichannel analyzer (OMA) and video systems will be modified to allow interfacing to the fiber optic systems. Knowledge of the spectral emission characteristics of the plume can provide important information on the health of the engine. Video coverage is needed to aid interpretation of the spectral data, as well as provide additional information about the plume/diffuser interaction. New methods for data acquisition and analysis will be developed to allow near real time evaluation and display of plume emission data in the Test Control Center.

W90-70676 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS ASCENT GUIDANCE DEVELOPMENT
Aldo Bordano 713-483-8179

The primary objective of this RTOP is to develop the requirements for a near fuel optimal or alternately loads minimum (within fuel constraints) ascent guidance system. The system will function pre-liftoff and throughout the ascent phases. Near liftoff update of the optimal ascent profile will be accomplished by incorporation of wind profile measurements in that time frame. All vehicle attitude and trajectory constraints will be satisfied by computing guidance and control commands real time. The system will adapt to real time dispersions or loss of single engine (within vehicle capability) in an optimal fashion. The requirements for new onboard sensors and computers will be developed. Wind profile measurement and aerodynamic data sensor requirements will be defined.

W90-70677 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
ADAPTIVE FUZZY LOGIC CONTROL
Robert Lea 713-483-8085

This research project will explore the use of new technologies for handling uncertainty in expert control systems development. Specifically, fuzzy controllers that adapt to a changing environment will be developed and tested in applications to automation and

robotics. A study of feasibility of the use of neural networks and other methods such as Kosko's Random Adaptive Bidirectional Associative memory for adaptive fuzzy control will be done. A prototype adaptive control system will be built and performance tested in an automation and robotics control test environment.

W90-70678 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
INTEGRATED AUTONOMOUS FLIGHT OPERATIONS FUNCTION SIMULATION
Richard Deppisch 713-483-8088

The goal of this project is to define and simulate a system architecture which supports the integration of multiple autonomous operations, real-time graphics, and complex dynamics simulation driven by real-time data. The objectives are to define the most effective method for implementing such a system, and investigate the application of new algorithms to autonomous space operations and integrate them into the existing space operations environment. Specifically, the task will address the automation of on-orbit trajectory control (e.g., rendezvous, proximity operations, traffic management, and collision avoidance) and robotic operations, consistent with typical operational constraints. A key element of this task is the demonstration of autonomous cooperative actions among program elements. This will require the integration of networking, internal control software, sensor algorithms, and the definition and testing of real-time interfaces with system hardware. Existing bench programs will be modified to simulate simultaneous man-in-the-loop and autonomous operations of multiple spacecraft to provide credible proof-of-concept. New robotics algorithms for autonomous robotic space operations will be tested in the Robotics Software Testbed, which provides a mechanism for performing systems integrations studies, e.g., networking, internal control software, and hardware design.

W90-70679 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
INTEGRATED FLIGHT CONTROL TRAINING PROCESS
Marilyn Kimball 713-483-2641

The objective of this project is to develop a proof-of-concept demonstration of a combined SCA/SMS (Shuttle Carrier Aircraft/Shuttle Mission Simulator) instructor station in a workstation environment. The project will be approached as follows: SCA/SMS instructor task analysis; evaluation of MCCU environment; prototype user displays; user evaluation of prototype and prototype modification; prototype of limited functional capabilities; user evaluation of prototype and prototype modification; requirements summary report, prototype expansion plan; expansion of prototype functionality; and test implementation of SMS/MCC (Space Mission Simulator/Mission Control Center) interface capabilities.

W90-70680 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
JSC/STANFORD COOPERATIVE AGREEMENT
Glyn LeBlanc 713-483-7015

This RTOP will explore solutions to data communications problems, specifically protocol performance issues and synchronized timing signal distribution on high-speed local area networks (LANs).

W90-70681 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
TELEMETRY AND COMMAND PROCESS APPLICATION LANGUAGE
Lorriane E. P. Rice 713-483-8477

The objectives are to: (1) research and develop an interpreted, English-like language that can both be used as a programming language and as a user interface language which is specifically tailored to Mission Control Center needs; (2) evaluate the reliability of this language during operations; and (3) develop a workstation tool that provides computation building and managing functions for ground support personnel. The approach of this investigation will be parallel. Southwest Research Institute shall perform the investigation of language concepts for mission support evaluate concepts, and work directly with the NASA Task Monitor in identifying requirements. IBM shall produce a prototype of the proposed application language programming environment and incorporate necessary research findings.

W90-70682 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT OF ADVANCED GRAPHICS LAB APPLICATIONS
Peter Galicki 713-483-8086

The objectives are to: (1) implement advanced graphics rapid prototyping functions including graphical tree manipulation based on user defined conditions, optimization of graphics operations to increase system performance, high-level engineering graphics library for non-graphics users, and incorporation of PHIGS/PHIGS + (Programming Hierarchical Interactive Graphics Systems) advanced capabilities; and (2) develop a solid-surface stereo helmet system based on the existing FM7 wire-frame system resulting in a low-cost stereo visualization system that can be utilized for part-task training and engineering analysis.

W90-70683 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
AUTOMATION AND EXPERT SYSTEMS APPLICATIONS TO SPACECRAFT OPERATIONS
Robert T. Savely 713-483-8105

The objective of this project is to continue development of AI-based application-independent planning and scheduling tools which can be applied to a wide variety of problems including STS ground flight operations planning and replanning. The approach is to develop a re-usable library of Ada and X-Windows components including representations for time, activities, and resources and algorithms for scheduling activities and resources; to make these facilities available in an interactive system for planning and replanning; and to use this system as a platform for the continuing development of advanced scheduling technology.

W90-70684 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT ENVIRONMENT FOR GENERAL PURPOSE ICAT
Robert T. Savely 713-483-8105

The primary objectives of this continuing project are: (1) to further refine and extend the architecture of the Intelligent Computer-Aided Training (ICAT) system originally developed to train flight dynamics officers in the procedures for Payload-Assist Module deploys from the Space Shuttle so that it can successfully address a wide variety of NASA training tasks; and (2) to develop a software environment designed for adapting the generic ICAT architecture to specific training tasks by providing an integrated set of tools for knowledge acquisition, user interface development, database modification, and knowledge base editing. The refinement and extension of the original ICAT architecture will be accomplished through the production of specific ICAT systems for diverse training applications at JSC and other operational centers. These applications include the training of Mission and Payload Specialists in using Spacelab systems and the training of engineers in performing testing and fault detection, isolation, and reconfiguration of Space Shuttle systems. The General Purpose Development Environment (GPDE) will be created by evaluating existing software tools, developing requirements for the tools that are a part of the GPDE, developing the software tools, and integrating those tools into a comprehensive, workstation-based environment for the rapid production and modification of ICAT systems. Such systems will support, not only Space Shuttle training, but also training for Space Station and future space transportation programs.

W90-70685 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED SOFTWARE DEVELOPMENT WORKSTATION
Robert T. Savely 713-483-8105

The primary purpose of this project is to investigate knowledge based techniques for software reuse. Software development is a

serious bottleneck in the construction of complex systems. An increase of the reuse of software designs and components has been viewed as a way to relieve this bottleneck. One approach to achieving software reusability is through the development and use of software parts composition systems. Early work in this project focused on the development of a knowledge based software components composition system prototype. While the functionality and performance of that prototype were adequate, our experience in building this system prompted us to investigate ways to exploit the use of knowledge representation, retrieval, and acquisition techniques to reduce the amount of manual effort spent in the creation of similar systems. The resulting system can be viewed as a knowledge based environment for the development of software components composition systems.

W90-70686 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE SHUTTLE MISSION OPERATIONS EFFECTIVENESS
J. F. Muratore 713-483-0796

The purpose of this RTOP is to immediately improve the mission effectiveness of Space Shuttle flight controllers by placing real time expert systems into Mission Control to perform automated telemetry monitoring and subsystem fault diagnosis. Under this effort (and related RTOP's from OAST and OSS) three real time expert systems have been placed in Mission Control and used by flight operations personnel to monitor telemetry and assist in flight decision making. Expert systems processing real time telemetry from the communications systems and the Space Shuttle Main Engines were used during the STS-26 flight. During STS-29 a Mechanical Expert System was used to monitor the Shuttle's hydraulic, landing gear and brake systems. Additionally during STS-29, a new application developed under this RTOP was added to Mission Control which used telemetry to reconstruct the Shuttle pilot's flight instruments on a color graphics CRT. This enables flight controllers on the ground to view the flight instruments from the pilot's perspective, enhancing communication between the flight crew and Mission Control.

W90-70687 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
EXPERT SYSTEM FOR CREW PROCEDURE EXECUTION
Harry K. Hiers 713-483-2036

The objective of this RTOP is the development of expert systems for the execution of crew procedures. Specifically, a rendezvous expert system is being developed as a crew assistant for the automatic evaluation and control of Shuttle rendezvous operations. The approach involves building on the existing prototype rendezvous expert system under the guidance of appropriate experts, and the evaluation of the system during real-time operation with a high fidelity Shuttle on-orbit simulation.

W90-70688 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
AUTOMATED GROUND SYSTEMS STATUS AND CONTROL
Clark D. Pounds 713-483-7080

The objective of this task is to provide enhanced automation of ground systems status and control through technology innovation. Specifically, this task will investigate and prototype new technology tools and techniques in the WPL (Workstation Prototype Lab) and TFCR (Transition Flight Control Room) which already exist for inserting new technology into the Mission Control Center and Shuttle Mission Simulator for NSTS (National Space Transportation System). This task presently has three specific sub-tasks of technology development: (1) Advanced Automation Environment; (2) Printer Controller AI; and (3) High Volume Data Storage Architecture. For the Advanced Automation Environment subtask the approach will be to analyze, select, and prototype tools and techniques, including AI, that provide for an overall environment for all ground system status and control applications to automate more of the human functions in a timely and cost effective manner. Also, this subtask will be concerned with promoting a HISE (Hardware Independent Software Environment) that allows for software independence from vendor hardware.

W90-70689 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
EECOM FLIGHT-TO-FLIGHT DATA OVERLAY
J. Steve McLendon 713-483-0766

The objective of this project is to introduce emerging high capacity data storage technologies into a real operational environment for flight-to-flight (FTF) data overlay and comparison. These technologies will be evaluated for their utility in both providing rapid access and search of data from previous Shuttle flights and for increasing the knowledge base and quality of the flight decision making process. The technologies selected include rewritable optical disks, high resolution color graphics, commercial off-the-shelf UNIX based workstation and data search tools, as well as telemetry processing and display equipment. All of these technologies will be integrated into a flight controller workstation for storage, archiving, and retrieval of discipline-specific flight data and support data bases at the workstation. The domain for this task will be the data normally monitored by the Electrical, Environmental, and Consumables Management (EECOM) Officer. The FTF overlay capability will initially be demonstrated in the laboratory (December 1989) and then moved to the EECOM Mission Planning and Support Room for evaluation in Shuttle Mission Simulations and actual Shuttle flight.

W90-70690 **906-22-03**
Lyndon B. Johnson Space Center, Houston, TX.
APPLICATIONS OF EXPERT SYSTEMS TO ONBOARD SYSTEMS MANAGEMENT
Chris Culbert 713-483-8080

The goal of this project is to demonstrate the application of multiple, cooperating expert systems to the management of operational activities that are typical of on-board systems. This effort focuses on planning activities associated with monitoring and controlling resource availability and usage from multiple subsystems such as electric power generation/distribution and propulsion subsystems. Our approach is to develop a hierarchy of expert systems that monitor operations for individual subsystems and then coordinate activities through higher levels of the hierarchy. Demonstration of the utility of such an architecture would help assure that incorporation of expert system automation into current vehicle upgrades and future vehicle designs could be carried out in an incremental and controllable manner.

W90-70691 **906-30-03**
Marshall Space Flight Center, Huntsville, AL.
AUTOMATED INTERFACE SYSTEM
Ernest B. Cross 205-544-7151

The objective of this RTOP is to design, fabricate and demonstrate an automated flight rated fluid and electrical interface system. The overall program objectives are to provide a functional element to the Satellite Servicer System demonstration and promote standardization of satellite servicing hardware. Specifically, the effort will develop an automated interface actuator for automated fluid transfer compatible with the Orbital Maneuvering Vehicle (OMV) and the emerging Satellite Servicer System (SSS). Mission requirements will be met by providing the capability of automatically connecting water, hydrazine, bipropellant, superfluid helium and electrical connectors.

W90-70692 **906-30-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INSTRUMENTED TOOL HANDLING SYSTEMS
A. K. Bejczy 818-354-4568

The general objective of this task is to develop, evaluate and demonstrate instrumentation subsystems to enable tool handling in teleoperator and telerobotic modes of servicing operations in space. The objective covers the mechanical, electrical, sensing, control and information display aspects of tool handling instrumentation covering a fairly general and representative set of tool handling tasks in teleoperator and telerobotic modes of space servicing operations. The technical approach to this task involves the following activities: (1) definition of needs and requirements in cooperation with users; (2) development of alternative design

concepts; (3) selection of a concept design; (4) development of engineering design for a selected concept; (5) fabrication and integration; (6) ground demonstration and evaluation; and (7) transfer to flight demonstration and flight validation. The technical approach will also be built on results of previous work and experience in related efforts at JPL and elsewhere.

W90-70693 **906-30-03**
Lyndon B. Johnson Space Center, Houston, TX.
SUPERFLUID HELIUM RESUPPLY COUPLING
Richard J. Schoenberg 713-483-6437

The objective of this effort is to develop, flight certify, and deliver a superfluid helium (He II) EVA resupply coupling. The coupling will initially be used on the SHOOT (Superfluid Helium On-Orbit Transfer) flight experiment. After its use on SHOOT, the coupling will be applicable for use on spacecraft requiring He II replenishment such as ASTROMAG, SIRTF, and AXAF. The design resulting from this effort will minimize heat leak to the He II, provide two failure tolerance against helium leakage, and be reusable for up to 20 resupply missions. The design can also be easily modified for automatic operation, thus greatly aiding in the standardization of a He II and cryogenic fluid resupply interface for orbital spacecraft servicing. The He II coupling development program consists of conceptual design, element development testing, preliminary design, coupling development testing, final design, flight qualification testing, flight hardware fabrication and acceptance testing, and flight hardware delivery to the SHOOT program.

W90-70694 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
OPTICAL COMMUNICATION THROUGH SHUTTLE WINDOW FLIGHT DEMONSTRATIONS
J. C. Lamoreux 713-483-1464

The objectives of this RTOP are: (1) to demonstrate the ability to transmit data and video between the crew cabin and the payload bay on the Shuttle, and (2) to measure the performance of the fiber optic system, key components of which have never before been used while exposed to the space environment. Flight hardware will consist of a box inside the crew cabin which will serve as a means of stimulating optical transmitters and receivers internal to the box with test signals. Optical beams will carry the test signals through the window. A fiber optic cable in the payload bay will receive the signals and carry them to an optical repeater. The test signals will then return to the cabin via a similar route where their performance will be measured and recorded.

W90-70695 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
LASER DOCKING SENSOR FLIGHT DEMONSTRATION
J. C. Lamoreux 713-483-1433

The objective of this RTOP is to develop and flight demonstrate a laser tracking system to very accurately measure relative range, bearing, and rates from a 3,280 to 0.1 foot range. The sensor will be mounted in either the Orbiter payload bay or the Satellite Servicing System (OMV) and will scan a passive target mounted onto a free flyer, such as the Spartan. The sensor will track the free flyer during deployment and retrieval maneuvers and display the information to the crew via a grid computer located in the aft space flight deck.

W90-70696 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
DEXTEROUS MANIPULATION DEMONSTRATION
L. G. Monford 713-282-1809

Current Remote Manipulator System (RMS) operations are severely limited in performing dexterous tasks due to a lack of force feedback to the RMS operator. This RTOP explores the feasibility of equipping the RMS with a force sensing capability that will display forces and torques encountered at the end of the RMS. To attain this end, a training/demonstration unit has been developed and installed at the Manipulator Development Facility (MDF), JSC Building 9A. Successful demonstrations have been performed on this device simulating heat pipe insertion, module servicing tool use, and opening and closing of drawers and latches. Completion of the force torque sensor and associated computer hardware and software will be completed by JPL. Design of a magnetic end effector and experiment carrier will be completed by JSC. A conceptual design review was completed in November, 1988. A preliminary design review is scheduled for March 21, 22, 1989. Hardware completion is scheduled for late FY-90.

W90-70697 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
PLASMA MOTOR GENERATOR EXPERIMENT
J. E. McCoy 713-483-5068

The objective is to demonstrate and study the operation in space of hollow cathode (HCA) plasma contactors to provide closure to and from the ionosphere of large currents at low voltage from both ends of an electrodynamic tether wire, to produce a Plasma Motor Generator system suitable for both on-orbit propulsion and electrical power generation. The approach will be to build and fly successive units of a low cost Payload of Opportunity experiment at increasing levels of current (initially 1 ampere, ultimately greater than 20 amperes) and low voltage between a pair of HCA's operating in orbit at sufficient separation (200 to 2,000 meters) to provide separation of their plasma clouds and low to moderate (40 to 400 volts) crossfield induced voltage.

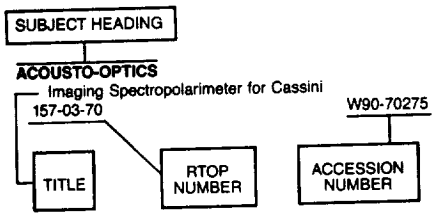
W90-70698 **906-30-04**
Marshall Space Flight Center, Huntsville, AL.
SMALL EXPENDABLE DEPLOYER SYSTEM
James K. Harrison 205-544-0629

The objective is to integrate the Small Expendable Deployer System (SEDS) into the Delta 2 expendable launch vehicle for proof-of-concept flight in the fall of 1990. The integration activity will consist of a SEDS/Delta 2 interface analysis, design analysis, documentation activities, physical integration, and launch and flight operations. The development of the SEDS hardware is scheduled to be completed by the end of 1989 with the integration work to begin in early 1990 and completed in time for a flight on a Delta 2 in the fall of 1990.

W90-70699 **906-30-04**
Goddard Space Flight Center, Greenbelt, MD.
SUPERFLUID HELIUM ON ORBIT TRANSFER (SHOOT)
Orlando Figueroa 301-286-7327

The Superfluid Helium On Orbit Transfer (SHOOT) is a STS based flight experiment designed to provide advanced technology for the replenishment of payloads in space with liquid helium. The critical components, tools, hardware, software, operations, and procedures required for the replenishment of payloads with liquid helium from the Shuttle and/or the Space Station will be defined by SHOOT. SHOOT will define the requirements to be met for payloads to be serviceable. The primary technical objectives of SHOOT are to: (1) demonstrate the controlled and verified transfer of liquid helium at rates exceeding 800 liters per hour; and (2) demonstrate crew controlled transfer using aft deck computers for diagnostic operations through the use of artificial intelligence software.

Typical Subject Index Listing



Listings in this index are arranged alphabetically by subject heading. The subject heading is a key to the subject content of the document. The title is used to provide a more exact description of the subject matter. The RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each subject heading in ascending accession number order.

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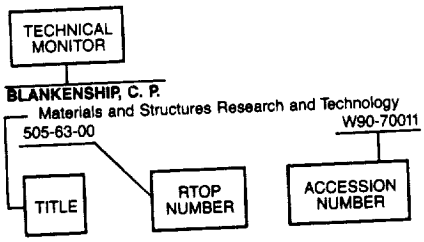

Listings in this index are arranged alphabetically by technical monitor. The RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each technical monitor in ascending accession number order.

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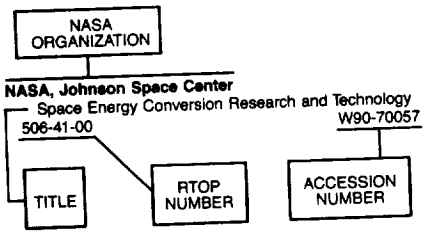
Typical Responsible NASA Organization Index Listing



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 RTOP number and accession number are included in each entry to assist the user in locating the citation and technical summary in the summary section. The titles are arranged under each responsible NASA organization in ascending accession number order.

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NASA, Johnson Space Center

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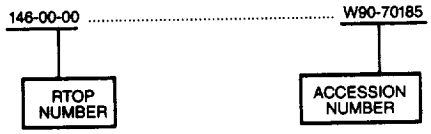

Each report covered in this publication has been assigned an RTOP number by the responsible NASA organization. They are listed here in ascending number order. By cross-referencing the accession number, the user can locate the citation and technical summary in the summary section.

RTOP NUMBER INDEX

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-101862		

4. Title and Subtitle	5. Report Date
Research and Technology Objectives and Plans Summary Fiscal Year 1990	February 1990
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Washington, DC 20546	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This publication represents the NASA research and technology program for FY 1990. 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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