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Research and Technology Objectives and Plans

Summary

Fiscal Year 1991
Research and
Technology Program

[redacted]

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Office of Management
Scientific and Technical Information Division
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INTRODUCTION

This publication represents the NASA research and technology program for FY 1991. 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: Glenn Fuller
Director, Resources and Management Systems Office (RB)

Arnold D. Aldrich
Associate Administrator for
Aeronautics, Exploration and Technology

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TYPICAL CITATION AND TECHNICAL SUMMARY

RESPONSIBLE NASA ORGANIZATION

RTOP ACCESSION NUMBER → **W91-70080** **(10) 506-59** ← **CURRENT RTOP NUMBER**

National Aeronautics and Space Administration, Washington, DC.

TITLE → **INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

Lee B. Holcomb 202-452-2747 ← **TECHNICAL MONITOR AND TELEPHONE**

RELATED RTOP → (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 support for National Research Council Computer Science and Telecommunications Board (CSTB) is to utilize the CSTB as a central asset for identifying the implications of new computational technologies on NASA operations and missions. The objective of the Advisory Group on Electron Devices (AGED) program is to provide effective coordination of NASA-sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on the Advisory Group on Electron Devices and its constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R and D procurement activities, long ranging R and D requirements, complementary work in other government agencies, and forecasts of new technical developments. ← **TECHNICAL SUMMARY**

OFFICE OF AERONAUTICS, EXPLORATION AND TECHNOLOGY

Aeronautics Research and Technology Base

Aerodynamics Research and Technology

W91-70001 **(21) 505-59**
Ames Research Center, Moffett Field, CA.
AERODYNAMICS RESEARCH AND TECHNOLOGY
F. R. Bailey 415-604-5065
(505-68-00; 763-01-00)

The objectives of this RTOP are to (1) 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; and (2) 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. A combination of computer simulations and experiments will be used to study flow over individual aerospace vehicle components, as well as complete configurations. Codes applicable to practical fluid dynamics problems will be developed to transfer the technology to the aerospace community. Wind tunnel experiments will be conducted to verify codes and validate prediction techniques. Analytical, ground-based and flight research investigations of a broad class of vehicles (subsonic transport, general aviation, rotorcraft, fighter/attack, powered lift and hypersonic) will be conducted. This RTOP also funds the Wind Tunnel Revitalization and Facility Maintenance Programs.

W91-70002 **(22) 505-59**
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, high speed shear layer development and applications of the modeling to computational fluid dynamics (CFD) codes for airframe/propulsion integration. Experimental, analytical and numerical studies 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 intergration for hypersonic aircraft. The research effort will be performed in-house and through university grants.

W91-70003 **(23) 505-59**
Langley Research Center, Hampton, VA.
AERODYNAMICS RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-864-6048

The objective of this RTOP 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 with DOD, industry, and other agencies are provided consistent with available resources.

W91-70004 **(55) 505-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AERODYNAMICS RESEARCH AND TECHNOLOGY
L. M. Mack 818-354-2138

This part of the Transition and Turbulence Physics Element of the Aerodynamics R and T 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 four problems: (1) the mechanisms by which various external disturbance sources interact with the boundary layer and produce instability waves and other disturbances (receptivity problem), the determination of the initial conditions of the instability waves, and the relative importance of competing influences on transition; (2) the propagation through the boundary layer of the instability wave trains and wave packets produced by either receptivity or by artificial means to the point where the final breakdown to turbulence starts; (3) the development of a method for the prediction of transition based on stability theory and knowledge of external disturbances; and (4) passive and active methods of transition control. As knowledge of transition is important for aircraft performance in all speed ranges and for all aerodynamics surfaces, the research will encompass two- and three-dimensional incompressible, subsonic, transonic, supersonic, and hypersonic boundary layers.

Propulsion and Power Research and Technology

W91-70005 **(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 carry out propulsion research and technology development at the discipline, component and subsystem levels that will lead to significant improvements in capability and efficiency. Advances in the propulsion systems of a variety of aircraft operating over a broad range of flight regimes will be pursued through an integrated program of in-house, contract and grant activities. In the subsonic regime, research is aimed at reducing the fuel consumption of rotary engines for general aviation by 40 percent and that of small turbine engines for rotorcraft and commuters by 30 percent, improving helicopter transmissions, and reducing the noise from high speed fans. Research in supersonic propulsion focuses on advanced concepts for STOVL, supersonic cruise and fighter/attack aircraft which include vectoring nozzles, the supersonic throughflow fan, variable geometry inlets and integrated flight/propulsion controls. Two key tools will continue to be developed to enhance these research efforts: advanced computational methods for numerically modeling internal flows and nonintrusive measurement techniques.

W91-70006 **(23) 505-62**
Langley Research Center, Hampton, VA.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 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. In the area of high performance aircraft the program focus is on providing basic information on the effects of advanced propulsion concepts on the performance and interference characteristics of advanced aircraft. Analytical and experimental studies using advanced facilities and techniques are utilized to investigate scramjet engine components, complete subscale engines, fundamental flow problems inherent to such engines, and engine/airframe integration. Advanced aircraft configurations and generic models are used for investigations of thrust vectoring and reversing, 2-D nozzles and propulsion control.

Materials and Structures Research and Technology

W91-70007 **(21) 505-63**
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
V. M. DeAngelis 805-258-3921
(505-59-00; 506-43-00)

The objective is to provide the materials and structures research and technology necessary for significant improvements in the performance, durability, and economy of future generation aircraft. In the area of hypersonics, techniques for extreme temperature (cryogenic to 3500 F) testing of advanced structural concepts and materials will be developed and applied; advanced high temperature structural measurement systems will be developed; and analytical modeling techniques will be applied and evaluated. In the area of airframe 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 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. Analytical capability 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.

W91-70008 **(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; (5) nondestructive evaluation of bonded fuselage structures and fatigue and fracture analysis for fuselage joints; and (6) 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.

W91-70009 **(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 R and D in advanced aerospace materials are provided by the National Materials Advisory Board, a unit of the National Academies of Science and Engineering. A Center for Computational Structures Technology (CST) has been established at the NASA Langley Research Center and will be an integral part of the University of Virginia. The interdisciplinary program in airframe materials and structures includes research on advanced metallic and composite airframe materials, properties of constituent fibers and matrix system for metal matrix and carbon/carbon materials, advanced structural analysis methods, fatigue response, environmental and thermal-structures response, and modeling and processing science for light weight airframe structures. The interdisciplinary program in high temperature engine materials focuses on metal matrix composites and ceramic matrix composites. Emphasis will be placed on understanding the processing and properties of these materials. Key activities include the development of high temperature fibers, composite micromechanics at high temperature including time-dependent behavior such as fatigue and creep, and the characterization and control of the fiber/matrix interface for both metal matrix composites and ceramic matrix composites.

W91-70010 **(22) 505-63**
Lewis Research Center, Cleveland, OH.
MATERIALS AND STRUCTURES
S. J. Grisaffe 216-433-3193
(510-01-00)

The major objectives of this RTOP are 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; developing and verifying 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 and 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.

Controls, Guidance, and Human Factors Research and Technology

W91-70011 **(10) 505-64**
National Aeronautics and Space Administration, Washington, DC.
CONTROLS, GUIDANCE AND HUMAN FACTORS
Lee B. Holcomb 202-453-2747
(505-68-00)

This RTOP provides support for the National Academy of Sciences (NAS) Commission on Behavioral 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.

W91-70012 **(21) 505-64**
Ames Research Center, Moffett Field, CA.
CONTROLS, GUIDANCE, AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. A. Albers 415-604-5070
(505-68-00; 506-71-00; 533-02-00)

The objectives of this RTOP are to develop guidance, control, and crew/cockpit/air traffic control (ATC) interaction technologies to enable design of more effective civil and military aircraft and to ensure safe, efficient aircraft operations. Research will be conducted on control systems for superaugmented aircraft as well as control, guidance, and display systems to achieve tactical path planning and more efficient ATC operations. Work will be done on the application of expert systems, computer vision, and guidance technology to enable automated rotorcraft flight in the nap-of-the-earth and maneuvering flight for fighter/attack aircraft. Human factors research will focus on understanding the tasks of piloting, air traffic control, and ground support operations in terms of the resources required from human capabilities; developing tools for the design and evaluation of crew/cockpit interfaces and operational procedures to support more effective crew performance; monitoring flight crew performance and assisting them in contingency operations; and improving aviation system reliability and precision. The approach will be to conduct analytic studies and evaluate concepts in flight simulation and in flight.

W91-70013 **(23) 505-64**
Langley Research Center, Hampton, VA.
CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(505-68-00)

This RTOP develops, validates and transfers to user communities the advanced R and T needed for continued improvements to all weather operational performance, efficiency, safety, competiveness, and reliability of U.S. subsonic, supersonic, and hypersonic aircraft. Specific objectives include development, validation, and demonstration of tools and methods for generating and evaluating reliable software and designing fault tolerant digital flight systems; multi-disciplinary efforts to develop and validate airborne windshear detection/avoidance techniques; application of advanced controls, displays and decision making aids to increase cockpit efficiency and enhance capacity of National Air Space (NAS); development of design methods for advance high performance aircraft guidance and control (G and C) systems; providing sensor technology for hypersonic aircraft; exploration of parallel computing system issues and evaluation of computer architectures; development and validation of models and crew performance measures for detection of pilot/crew workload and awareness state; and investigation of computing technologies to achieve large increases in performance in next 5 years. The approach to be taken includes establishing basic concepts and theories, developing and validating new concepts and innovative techniques through analysis, simulation and laboratory testing, and finally, demonstration of the most promising concepts in flight tests.

W91-70014 **(51) 505-64**
Goddard Space Flight Center, Greenbelt, MD.
CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
John T. Dalton 201-286-8623
(505-66-00)

The objective of this RTOP is to provide appropriate support at the Wallops Flight Facility (WFF) airfield for Office of Aeronautics, Exploration and Technology (OAET) projects. Operational support includes project coordination; program aircraft fuel and ground servicing; control tower management of the Goddard Flight Flight Center (GSFC)/Wallops Flight Facility research airport control area; airport maintenance; shop support; automatic data processing operations; synthetic aperture radar (SAR), chase, and other aircraft flight services; crash, fire, and rescue services; specialized instrumentation and miscellaneous equipment.

Flight Systems Research and Technology

W91-70015 **(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 R and T program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil aircraft 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.

W91-70016 **(21) 505-68**
Ames Research Center, Moffett Field, CA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
D. H. Gatlin 805-258-3166
(533-02-00; 505-59-00)

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. This will include the necessary supportive development of testing techniques and instrumentation to enhance data accuracy as well as the acquisition of new and previously unattainable information. Research will be conducted as part of the NASA High Angle-of-Attack Technology Program. Flight experiments will be conducted using the High Alpha Research Vehicle (HARV) while full-scale wind-tunnel tests will be conducted in the NFAC for correlation with flight. The long term goal is to develop flight validated predictive techniques by correlating flight and wind tunnel measurements with those generated by CFD analysis. Unconventional approaches for high alpha flight control and maneuvering will be investigated, including pitch and yaw thrust vectoring and both strake and pneumatic forebody vortex control. In support of the NASA Supersonic Short Take-off and Vertical Landing (STOVL) Program, a focused technology program will be conducted, including piloted simulation using the Vertical Motion Simulator and ground environment model tests. Non-intrusive optical air data laser systems will be evaluated through a joint NASA/DARPA program focusing on the capabilities of the technology as a measurement technique in the flight environment.

W91-70017 (23) 505-68
Langley Research Center, Hampton, VA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-864-6048
(533-02-00)

The objective of this research is to develop advanced methods and vehicle concepts needed to significantly increase fighter maneuverability, considering such effects as high angle of attack, separated flow conditions, vortex flows, thrust vectoring, and STOVL. Flight experiments will be used to validate key elements. Another objective is to improve our knowledge of severe storm atmospheric processes as they affect the design and safe and efficient operation of aircraft and aircraft systems. Existing experimental programs will be continued to provide additional data for improving the detection and avoidance of severe storm hazards, and for the development of design and operating criteria for those hazards which cannot be avoided.

Systems Analysis

W91-70018 (23) 505-69
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
R. V. Harris, Jr. 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. Although research addresses vehicles for both civil and military applications across the speed range, current emphasis is focused on high speed transportation needs and identification of the most promising future vehicle concepts based on an evaluation of the technical, economic, and timing issues.

W91-70019 (21) 505-69
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
G. H. Kidwell, Jr. 415-604-5886

The objective is to provide information for guiding the planning of advanced aircraft research and technology development programs. Current efforts are directed toward the High-Speed Rotorcraft and Generic Hypersonics programs. Both in-house and contracted studies will be undertaken to perform the technical evaluation and sensitivity analysis of fully integrated designs. Also, in-house studies addressing the application of advanced technology to baseline aircraft will be performed as potentially-high value concepts are identified. Additionally, advanced methodology development will be directed to both improve in-house capabilities and to foster design productivity benefits in industry.

W91-70020 (22) 505-69
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
D. C. Mikkelson 216-433-5637
(537-01-00)

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

W91-70021 (10) 505-69
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Cecil C. Rosen 202-453-2789

This effort supports the overall planning and management of the aeronautics R and T program. Activities include a studies contract in support of Office of Aeronautics, Exploration, and Technology (OAET) aeronautics technology program requirements, assessments, planning and advocacy, as well as membership in the Radio Technical Commission for Aeronautics (RTCA) and funding for the University Advanced Aeronautical Design Studies Program.

Interdisciplinary Technology

W91-70022 (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 two program elements (1) The Graduate Program in Aeronautics (GPA), and (2) 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: 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 a 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.

W91-70023 **(10) 505-90**
National Aeronautics and Space Administration, Washington, DC.
INTERDISCIPLINARY TECHNOLOGY
Glenn C. Fuller 202-453-2790

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

W91-70024 **(22) 505-90**
Lewis Research Center, Cleveland, OH.
INTERDISCIPLINARY TECHNOLOGY
M. E. Goldstein 216-433-5825

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 Ohio Aerospace Institute (Joint University Institute). The program is carried out primarily through grants which are selected by the Chief, Office of University Affairs, 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.

W91-70025 **(21) 505-90**
Ames Research Center, Moffett Field, CA.
INTERDISCIPLINARY TECHNOLOGY
C. Smith 415-604-5113

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. The Aeronautics Graduate Research Program provides grants to support graduate training and research in aeronautics. A significant portion of the training will be through student research conducted at Ames Research Center. The Joint University Institute element provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics. The Institute promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics.

Aeronautics Systems Technology Programs

Materials and Structures Systems Technology

W91-70026 **(22) 510-01**
Lewis Research Center, Cleveland, OH.
ADVANCED HIGH-TEMPERATURE ENGINE MATERIALS TECHNOLOGY
J. R. Stephens 216-433-3195
(505-66-00)

The major objective of this RTOP is to develop the technology for revolutionary advances in materials to enable the development of 21st century transport aircraft propulsion systems having greatly decreased specific fuel consumption, reduced direct operating costs, improved reliability, and extended life. To accomplish this objective very high temperature, lightweight material systems and the associated processing technologies will be developed. This includes the development of advanced metals, fibers, and intermetallic matrix composites; advanced ceramic fibers and ceramic matrix composites; 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.

W91-70027 **(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 solid 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 uncertainties in the response, fracture, durability and life of composite structures.

W91-70028 **(23) 510-02**
Langley Research Center, Hampton, VA.
ADVANCED COMPOSITE MATERIALS TECHNOLOGY
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 the required scientific basis for verified innovative light-weight, 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

W91-70029 **(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.

W91-70030 **(21) 532-06**
Ames Research Center, Moffett Field, CA.
ADVANCED ROTORCRAFT TECHNOLOGY
W. J. Snyder 415-604-6570
(505-61-51; 505-59-36)
The objective of this program is to advance rotorcraft systems technology for reduced noise and for high subsonic speed capabilities to enable advances in military and civil rotorcraft vehicles. Rotorcraft noise methodology will be improved by the acquisition of a modern airloads data base and the refinement of predictive methods. Semi-empirical design methods will be improved and analytical and Computational Fluid Dynamics (CFD) codes will be validated. Scaling laws will be investigated by comparison of small- and large-scale model data with flight test data. Analytical capabilities, ground based facilities and flight research vehicles will be used to advance technology for high-speed rotorcraft. CFD techniques will be developed to accelerate high-speed designs. Technology requirements for civil applications of the tilt rotor will be assessed. Advanced high speed rotorcraft concepts will be investigated for potential development and future technology needs will be identified.

High-Performance Aircraft Systems Technology

W91-70031 **(21) 533-02**
Ames Research Center, Moffett Field, CA.
HIGH-PERFORMANCE FLIGHT RESEARCH
K. E. Hodge 805-258-3179
(505-68-00; 505-63-00)
Generic high angle-of-attack research will be continued with an F-18 test aircraft. Under the 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 conduct single engine flight testing, to be followed by a design and development effort to optimize the total integrated propulsion and flight control systems for two engine full envelope operation. Integrated flight/propulsion control techniques will be investigated to minimize the impact of aircraft flight control failures. The modified YAV-8B Harrier will be used to validate design 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. Final analysis and reporting of the results of the flight phase of the Supersonic Laminar Flow experiment on F-16XL Ship 1 will be initiated in FY-91. A separate Supersonic Laminar Flow flight experiment will be initiated on F-16XL Ship 2 following flight evaluation of the baseline aircraft and engine.

W91-70032 **(22) 533-02**
Lewis Research Center, Cleveland, OH.
HIGH-PERFORMANCE FLIGHT RESEARCH
Peter G. Batterton 216-433-3912
(505-68-00; 505-62-00)
Generic high angle-of-attack research will be conducted with an F-18 test aircraft. Of particular interest are the effects of high air flow angles due to aircraft maneuvers and the interaction with the aircraft forebody, the resulting flow field as ingested by the inlet system, and the response of the inlet to such flow fields. The objective is to use results of the aircraft experiments to correlate wind tunnel and Computational Fluid Dynamic analyses.

W91-70033 **(23) 533-02**
Langley Research Center, Hampton, VA.
HIGH-PERFORMANCE FLIGHT RESEARCH
R. V. Harris, Jr. 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

W91-70034 **(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.

W91-70035 **(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 ducted and unducted 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.

W91-70036 **(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

W91-70037 **(21) 536-01**
Ames Research Center, Moffett Field, CA.
NUMERICAL AERODYNAMIC SIMULATION (NAS)
R. Deiss 415-604-4501
(536-02-00)

The objectives of the Numerical Aerodynamic Simulation (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, Exploration and 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.

W91-70038 **(21) 536-02**
Ames Research Center, Moffett Field, CA.
NAS OPERATIONS
R. Deiss 415-604-4501
(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, Exploration and 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

W91-70039 **(22) 537-01**
Lewis Research Center, Cleveland, OH.
ATMOSPHERIC EFFECTS
L. H. Fishbach 216-433-5633
(505-69-00; 537-02-00; 537-03-00)

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 effects 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, noise suppression concepts and combustors to identify the most promising concepts for high speed civil transports.

W91-70040 **(23) 537-01**
Langley Research Center, Hampton, VA.
ATMOSPHERIC EFFECTS
R. V. Harris, Jr. 804-864-6048
(505-69-00; 537-02-00; 537-03-00)

The overall objective of this work is to provide guidance and direction to aeronautics/propulsion research and technical 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. The best 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 oversight committee of experts in the field will review the results that can be used to establish an acceptability emissions budget and/or flight altitudes. Aircraft systems studies will be conducted to determine the viability of technological solutions for environmental concerns and to identify high payoff technology developments that will enable an economically viable and environmentally acceptable HSCT. Technical solutions for various environmental concerns will be combined to determine the synergistic effects on the aircraft operational characteristics. Aircraft operational methods and/or flight paths will be developed to enhance environmental compatibility. The studies will provide necessary inputs to assess community noise and sonic boom levels, and also provide valuable guidance to the discipline specialist in selecting the most promising solution or combination of solutions.

W91-70041 **(23) 537-02**
Langley Research Center, Hampton, VA.
EMISSIONS AND SOURCE NOISE
C. P. Blankenship 804-864-6005
(537-03-00; 505-59-00)

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 Air Regulation 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.

W91-70042 **(22) 537-02**
Lewis Research Center, Cleveland, OH.
EMISSIONS AND SOURCE NOISE
R. J. Shaw 216-433-3942
(537-01-00; 537-03-00)

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 36-Stage III noise levels. The overall approach is to first develop and validate the required computational prediction codes using existing analysis tools wherever appropriate. Small scale laboratory and wind tunnel experiments will be conducted to improve the understanding of the key physics of both the noise and emissions problems and to provide code calibration/validation data. Wind tunnel tests of subscale nozzle configurations will then be conducted to demonstrate acceptable aerodynamic and acoustic performance across the take-off/transonic cruise performance range. Combustor subcomponent tests will be conducted and followed by rig tests of prototype combustor configurations to demonstrate acceptable NOx emissions levels and combustor efficiency.

W91-70043 **(21) 537-02**
Ames Research Center, Moffett Field, CA.
EMISSIONS AND SOURCE NOISE
R. L. Kurkowski 415-604-6569
(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 Progran (HSRP) is to develop NOx control technologies such that NOx 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 transport must comply with Federal Air Regulation Part 36 - Stage III 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.

W91-70044 **(21) 537-03**
Ames Research Center, Moffett Field, CA.
COMMUNITY NOISE AND SONIC BOOM
R. L. Kurkowski 415-604-6569
(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) 36 STAGE III 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.

W91-70045 **(23) 537-03**
Langley Research Center, Hampton, VA.
COMMUNITY NOISE AND SONIC BOOM
R. V. Harris, Jr. 804-864-6048
(537-01-00; 537-02-00)

The objectives are to provide understanding, innovative concepts, predictive capability, and minimization methodology for the acoustic disturbances and sonic boom generated by the operation of a High Speed Civil Transport (HSCT). An HSCT must be compliant with the intent of FAR 36 Stage III 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.

Space Research and Technology Base

Aerothermodynamics Research and Technology

W91-70046 **(21) 506-40**
Ames Research Center, Moffett Field, CA.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
J. O. Arnold 415-604-5265
(505-59-00; 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 and the aerodynamic performance of the vehicle. The codes will yield solutions for the full Navier-Stokes equations for chemically reacting and radiating gases. 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 of thermochemical nonequilibrium processes will be performed to provide a database and to develop an understanding of coupled rotation-vibration-dissociation phenomena and nonequilibrium radiation in high enthalpy, hypervelocity flows. Research for future experimental ground based facilities to study real-gas hypersonic flows will be conducted. Candidates for study are an advanced ballistic range and arc-driven hypersonic wind tunnels.

W91-70047 **(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, entry, and aerobraking 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 convecting and radiative 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. The theoretical program requires extensive use of current supercomputers and parallel computers and utilization of future computer technology.

Space Energy Conversion Research and Technology

W91-70048 **(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. Generic missions guide systems level analyses which identify technological options with maximum system leverage/impact. 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. Areas include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, solar thermal and dynamic systems, advanced radiator concepts and surfaces, thermal control of advanced power electronics, and supporting technology for the SP-100 nuclear power system. 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.

W91-70049 **(51) 506-41**
Goddard Space Flight Center, Greenbelt, MD.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Roy McIntosh 301-286-3478

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 instrumentation, sensors, and other heat dissipating equipment. Moderate to low temperature and long life applications will be stressed. This work will be accomplished through: (1) research into basic thermo-fluid phenomena under micro and partial gravity; (2) development and test of various two-phase components and test verification; and (3) small flight experiments.

W91-70050 **(55) 506-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
C. P. Bankston 818-354-6793

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 40 kW. The principal goal is to develop power technologies that minimize power system mass, volume and parts count. 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 1 W/cu in. to more than 10 W/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.

W91-70051 **(10) 506-41**
National Aeronautics and Space Administration, Washington, DC.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
Robert E. Anderson 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.

W91-70052 **(23) 506-41**
Langley Research Center, Hampton, VA.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
W. R. Hook 804-864-6055

This research, part of the power management program includes studies and technology development for remote space-power distribution. The goal is to assess the technical feasibility and develop key technologies for laser-beamed-power transmission, in support of civil space missions, for propulsion and for electric-power distribution. Solar-pumped laser oscillators and amplifiers are conceived, tested, and modeled. Near-term objectives are to define efficient solar-pumped lasers and to establish scaling laws for extrapolating to high-average-power operation. Experimental research and modeling define and develop large-scale coherent combinations of electrically driven diode lasers. 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. Both experimental and theoretical research on this concept is directed toward efficient conversion of potential beamed-power wavelengths in the near infrared. To assess the advantages of space-power transmission and to guide the laser and converter research, limited trade and application studies are performed.

Propulsion Research and Technology

W91-70053 **(10) 506-42**
National Aeronautics and Space Administration, Washington, DC.
PROPULSION RESEARCH AND TECHNOLOGY
Robert E. Anderson 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.

W91-70054 **(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 other advanced propulsion system concepts to identify critical technology development requirements, and to develop and demonstrate feasibility for the most promising near-term concepts so they may be ready for mission application in the 1990s. The feasibility of both ion and magnetoplasmadynamic (MPD) thrusters has been shown by previous analyses and experiments. Work in FY-91 will emphasize the theoretical design and experimental development of ion thrusters and ion propulsion systems which significantly reduce the difficulty of thruster life testing. Plasma acceleration in a 100 kW class, applied-field MPD thruster will also be studied experimentally. Research will be carried out to identify propulsion concepts which offer substantial performance increases over today's propulsion systems for the ambitious missions of the 21st Century. Propulsion technologies to be studied include electric, advanced nuclear, microwave or laser, plasma engines, and extraterrestrial resource utilization. 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. Concepts found through study to merit further consideration will be evaluated in proof-of-concept experiments.

W91-70055 **(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 propulsion technology for future Earth-to-Orbit, Earth orbiting platforms and spacecraft, orbital transfer vehicles, space 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. Advanced high performance, reusable Earth-to-Orbit propulsion systems will extend component service life. 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. 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.

Materials and Structures Research and Technology

W91-70056 **(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 the following: (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. The objective of the NASA Atomic Oxygen Effects Test Program effort is to quantify atomic oxygen erosion yield dependencies of well characterized materials exposed to specific simulated low earth orbital environments.

W91-70057 **(55) 506-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Jovan Moacanin 818-354-3178

The objective is to develop and demonstrate advanced technologies in the areas of materials for dimensionally stable large structures and science instruments, and advanced methodologies for the design of large structural systems. Analytical and experimental research will be conducted to develop materials with high dimensional stability for observational and communication systems such as reflectors, antennas, optical benches and interferometers. For the near term, the emphasis will be on the development of carbon-carbon composites as a representative class of materials with potential dimensional stability and tolerance toward exposure to the space environment. Emphasis will be on establishing quantifiable relationships between processing variables and properties. In parallel, studies will be conducted aimed at understanding physical/chemical processes that limit dimensional stability of structural materials. In order to enable the future development of large ultralow scattering optics for astrophysics application, theoretical and experimental studies will be performed on new approaches to depositing uniform coatings on large surfaces. Research on flexible structures will emphasize adaptive structures and will include development of a concept of an adaptive deployable structure.

W91-70058 **(21) 506-43**
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. O. Arnold 415-604-5265
(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, 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 compared with experiments 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 subjected to systematic analysis and testing to qualify for defined end use. Improvements in arc-plasma technology will assure that NASA materials testing continues to be accomplished in state-of-the-art test facilities.

W91-70059 **(72) 506-43**
Lyndon B. Johnson Space Center, Houston, TX.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. L. Koontz 713-483-5906

Task 1 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. Task 2 also provides 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.

W91-70060 **(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 improve 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 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.

W91-70061 **(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.

W91-70062 **(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.

Space Flight Research and Technology

W91-70063 **(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.

W91-70064 **(51) 506-48**
Goddard Space Flight Center, Greenbelt, MD.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
Roy McIntosh 301-286-3478

The objective of this task is to provide support to OAET experimenters pertaining to the NSTS payload integration processes and to provide specific support for unique hardware development for the OAET-1 Hitchhiker mission.

W91-70065 **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
Robert L. Giesecke 713-283-5340

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 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 assessment for selected proposals prior to initiation of Phase 1 concept and development Phase 2 engineering studies; and Phase 3/4 hardware development and flight; make recommendations concerning complementary/compatible experiment groupings; and possible experiment flight opportunities.

W91-70066 **(21) 506-48**
Ames Research Center, Moffett Field, CA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. O. Arnold 415-464-5265
(506-40-00; 506-43-00)

The objective is to utilize the Space Shuttle as a flight research facility to obtain data to support and augment the research and technology base for advanced space transportation systems. A better understanding of thermal protection system (TPS) performance during Orbiter entry will allow creation of options for TPS cost and weight reductions and improved TPS temperature and durability capabilities for the current Space Shuttle and advanced aerospace/hypersonic vehicles. This experiment will take advantage of the actual entry heating environment that cannot be fully simulated in ground facilities. The experiments 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. The experiment will be designed, developed, and fabricated through both in-house and contract efforts.

W91-70067 **(22) 506-48**
Lewis Research Center, Cleveland, OH.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
W. J. Masica 216-433-2864
(589-01-00)

The objective of the Space Flight R and T program is to provide experiment support for the definition and conceptual design of in-space technology experiments to bring the R and T base technology forward to flight and provide the aerospace community with increased access to the national space facilities. The program elements contained in this submittal include the Industry/University Experimental Studies, and In-Space Research. The Experimental Studies, provide definition and conceptual design studies of proposed in-space technology experiments which enable or enhance future exploration missions, improve space station capabilities, increase science spacecraft efficiency and validate essential system components for advanced transportation systems. The In-Space Research provides experiment support, test facilities, accommodation assessment, and development of unique spacecraft hardware required to conduct in-space technology experimentation that will enable verification and validation of the technologies using the nation's space facilities.

W91-70068 **(55) 506-48**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
C. P. Bankston 818-354-6793

Eight technology themes have been identified within the In-Step Space Technology Experiments Program. For all eight themes, JPL will provide programmatic support to NASA-HQ in areas of planning, proposal evaluation and review, technology oversight, management, and coordination with team members from other centers. Technology working group meetings and/or workshops for each theme will be attended and documents describing the working groups recommendations will be produced as required. In addition, JPL will chair the sensors theme group (one of the eight). This effort also includes a limited budget for responding to the expected Announcement of Opportunity for FY-91 flight experiment definition phase proposals. Also, work will continue on defining a space experiment for measuring the contamination from Earth-storable bipropellant rocket plumes. JPL is responsible for the management and execution of the work with participation by LeRC, GSFC, and JSC.

W91-70069 **(62) 506-48**
Marshall Space Flight Center, Huntsville, AL.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-1762

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

W91-70070 **(22) 506-49**
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
H. W. Brandhorst 216-433-6149

The Systems Analysis RTOP contains two elements: Space Science Systems, and Space Station Systems. The objective of this effort is to develop improved analysis/modeling capabilities, to identify technology requirements and to evaluate the benefits of emerging technologies for advanced missions. Element 21 is to identify, assess, and prioritize high leverage bus technologies for space science. The approach calls of liaison with industry, and both in-house and contracted studies. Results from the studies will be used in planning the future technology initiatives. Element 31 is to define and develop system level technology requirements for Advanced Power, and Propulsion Systems and to evaluate their impact on the Evolutionary Space Station Elements including: Fuel Depots; Assembly Nodes; Science, Commercial and Communications Platforms; and Supporting Vehicles. The results of these studies will be used to develop evolutionary systems requirements data bases and to identify advanced technologies with strong benefits and required in-space technology development.

W91-70071 **(55) 506-49**
Jet Propulsion Lab., California Inst. of Tech., Pasadena
SYSTEMS ANALYSIS
Robert Gershman 818-354-9330

The objectives are to identify critical technology needs for future high priority NASA missions and to assist in the formulation of the necessary supporting technology development programs. Studies will continue to contribute to technology planning for the Astrophysics, Planetary and Global Change missions. A new thrust, integrated information systems analysis, will lead to better understanding of multimission information systems requirements and, consequently, to identifying critical technology needs. 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.

W91-70072 **(21) 506-49**
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
H. H. Arnaiz 805-258-3176
(505-59-00)

The objective of this effort is to conduct basic aerodynamic and aerothermal flight research in order to allow timely and reliable design of advanced hypersonic transportation systems. Critical gaps exist in the current data base which may not be filled with conventional test and analysis. Some of these gaps can be closed through experiments which can be conducted on existing and proven flight vehicles at reasonable cost. Results will allow calibration and validation of the tools needed to design mission-oriented vehicles. Related test technique development must be addressed concurrently. Another objective of this RTOP is to conduct research on advanced remote sensing technology leading to the development of airborne and spacecraft imaging instrumentation optimized for the measurement of the biochemical composition of the plant canopies of Earth's biosphere. The approach to be taken will be based on the Research and Development recommendations of a scientific workshop held in the summer of 1990. Laboratory investigations of spectroscopic sensing elements (detector arrays, spectral filters, optics, lasers, and so on) will be conducted to determine performance, permitting new sensing techniques such as imaging derivative spectroscopy. These investigations will be done in conjunction with greenhouse experiments on selected plants.

W91-70073 **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, TX.
SYSTEMS ANALYSIS
C. Wilson 713-283-5320

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 four tasks. Task 1 investigates the human-computer interface requirements needed in an increasingly complex multi-task environment. Task 2 investigates the benefits to the Space Station Freedom program of utilizing Advanced Automation and Expert Systems Technology for performing diagnosis of system failures. 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. This RTOP will also provide project management and data base support for the Independent Research and Development (IR and D) activity at the Johnson Space Center as required by NMI 5115.2A. It is particularly necessitated by JSC's role as Government-wide lead organization for the McDonnell-Douglas Space Station Division assigned by the Office of Aeronautics and Space Technology.

W91-70074 **(51) 506-49**
Goddard Space Flight Center, Greenbelt, MD.
SYSTEMS ANALYSIS
Henry H. Plotkin 301-286-6185

The objective is to identify high leverage technologies that will enable or enhance key future NASA missions such as those within the Astrophysics Observatory programs, the Space Exploration Initiative, and Mission to Planet Earth. Science Committees and Workshops, will select specific scenarios likely to shape NASA's technology needs beyond Year-2000, which then will be modeled and analyzed in sufficient detail to derive technical challenges and to recommend OAET technology programs. In High Energy Astrophysics, a Working Group will extend the results of the HEA panel of the Astrotech-21 study and select critical detector technologies. A lunar surface observatory for high energy x ray or gamma ray astrophysics will be designed in order to develop estimates of challenges and technology priorities in optics, structures, assembly, operations, data systems, controls, and remote operations, as well as detectors. A study of the information systems requirements of Mission to Planet Earth, with its constellation of satellites, platforms, ground facilities, and remote investigators will lead to concepts for extending the EOS Information System network architecture and for new spaceborne data processing, communication, and computer technology.

W91-70075 **(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 to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technolgy 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.

W91-70076 **(10) 506-49**
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Gregory M. Reck 202-453-2733

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

University Space Research

W91-70077 **(55) 506-50**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
UNIVERSITY SPACE RESEARCH
J. D. Burke 818-354-3201

The objectives are (1) to apply JPL skills in support of space systems engineering design courses at selectd universities, and (2) to support summer residencies at JPL of selected students from those universities. The approach uses a designated JPL mentor who works with university faculty and students during the academic year providing or arranging for JPL support in the form of lecturers from JPL, information from JPL and NASA sources consulting and attendance at preliminary and critical design reviews. The JPL mentor is also expected to attend annual NASA/USRA meetings, and to consult as appropriate with USRA, other Center mentors and faculty at other universities in the program.

W91-70078 **(10) 506-50**
National Aeronautics and Space Administration, Washington, DC.
UNIVERSITY SPACE ENGINEERING RESEARCH
Gregory M. Reck 202-453-2733

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

W91-70079 **(22) 506-50**
Lewis Research Center, Cleveland, OH.
UNIVERSITY SPACE RESEARCH
F. J. Montegani 216-433-2956

The overall objective is to support and maintain long term collaborative research involving the Lewis Research Center and the Ohio Aerospace Institute. Collaborative research involves advanced space power and propulsion and related areas of joint interest to the NASA and the participants in the Ohio Aerospace Institute.

Information and Controls Research and Technology

W91-70080 **(10) 506-59**
National Aeronautics and Space Administration, Washington, DC.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Lee B. Holcomb 202-452-2747
(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 support for National Research Council Computer Science and Telecommunications Board (CSTB) is to utilize the CSTB as a central asset for identifying the implications of new computational technologies on NASA operations and missions. The objective of the Advisory Group on Electron Devices (AGED) program is to provide effective coordination of NASA-sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on the Advisory Group on Electron Devices and its constituent working groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R and D procurement activities, long ranging R and D requirements, complementary work in other government agencies, and forecasts of new technical developments.

W91-70081 **(21) 506-59**
Ames Research Center, Moffett Field, CA.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
C. R. McCreight 415-604-6549
(590-31-00; 505-64-00)

One objective is to develop advanced infrared detector array technology for future astronomical applications. The array technology is applicable to low- and moderate-background applications throughout the infrared spectrum and will directly benefit programs such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). These activities include extensive in-house characterization. The second objective is to develop real time optical processors for air and spaceborne applications. This research is centered around development of compact optical systems for real time autonomous vision and high bandwidth matrix operations applied to data analysis and the control of large structures. The approach involves extensive in-house technology demonstrations coordinated with user requirements for applications in autonomous construction, exploration, and control. A third 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, including sparse distributed memory (SDM), which permit 'learning' and 'image recognition'. This work will be carried out by Ames' Research Institute for Advanced Computer Science.

W91-70082 **(22) 506-59**
Lewis Research Center, Cleveland, OH.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Denis J. Connolly 216-433-3503
(590-31-00)

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

W91-70083 **(23) 506-59**
Langley Research Center, Hampton, VA.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(590-14-00)

This RTOP covers the following activities: fundamental and applied guidance, navigation, and control (GN&C) research and technology for advanced spacecraft, space transportation systems and large, flexible space structures/platforms; research on new components and system level concepts for space data and communication systems (semiconductor lasers, multibeam feeds for millimeter wave space antennas); and development of solid state IR and far-IR detectors, laser materials, and transmitters for active remote sensors supporting aircraft and space-based earth science studies. The approach includes developing basic control theories, applying advanced modeling techniques and on-line identification in conjunction with dynamic models of large flexible space systems, advanced transportation system concepts and reentry vehicles, and evaluating resulting the GN&C system in simulations and ground and flight test programs; improvement of IR and far-IR sensors and sensor system components through theoretical studies and single crystal materials development; conducting basic Research and Development studies and developing system level models to establish feasibility, building proof-of-concept or engineering validation hardware and software to demonstrate technology readiness.

W91-70084 **(51) 506-59**
Goddard Space Flight Center, Greenbelt, MD.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Henry H. Plotkin 301-286-6185

This RTOP includes research in computer sciences, high data rate space optical communications, space science sensor systems, and dynamic controls analysis. Environments are developed for software management and knowledge based software engineering. Automated approaches are developed for encoding and analyzing multispectral imaging data. Artificial intelligence (AI) approaches are used to access and manage large, diverse, and complex data and knowledge bases. Concurrent processing algorithms are developed for computers having many parallel high speed processors. Support to the University/Government Center for Space Data and Info Systems (CESDIS) is continued. Research is conducted in laser communication transmitters and wideband optical receivers. Advanced detectors are being developed which greatly improve spectral and spatial resolution for future x ray, gamma ray and cosmic ray astrophysical and planetary observations. An efficient, long life advanced cryogenic cooler is being developed for the future Earth Observing System.

W91-70085 **(55) 506-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objective is to develop advanced spacecraft technologies in the areas of computer science, data systems, photonics, optical communications, sensors, and controls. Computer science research will demonstrate an easy to use and inexpensive cataloging technique to facilitate software reuse. Data systems work will develop neural network based erasable, programmable, non-volatile synaptic memories to demonstrate their unique potential for solving complex information processing problems. Photonics work will begin developing a monolithic optoelectronic integrated circuit to interface between fiber optics and electronics for spacecraft interconnects. Optical communications research will develop laser transmitters for free space communications systems. Sensors research will develop unique molecular beam epitaxy techniques to make devices with highly specialized infrared detection characteristics. Other sensor research will produce high temperature superconducting thin films with optimized microwave response properties. Controls research will produce new computational design tools that will reduce the time and cost required to develop spacecraft control systems. Advanced metrology concepts with nanometer level performance will be developed for large optical space interferometers. System identification and adaptive control research will develop new guidance and control architectures to enable high performance autonomous aeromaneuvering vehicles.

W91-70086 **(62) 506-59**
Marshall Space Flight Center, Huntsville, AL.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
J. F. Macpherson 205-544-5936

The overall objective of this research is to define, develop, and demonstrate advanced control concepts for the stabilization and control of future spacecraft, payload point systems, and advanced transportation vehicles. The work is focused on 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 systems operational cost and at the same time enhance system reliability and utility. In the third area, computational methodologies will be explored, developed and investigated to enhance dynamic and control procedures for large order systems.

W91-70087 **(72) 506-59**
Lyndon B. Johnson Space Center, Houston, TX.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
J. Sunkel 713-483-8591

The objective is to develop and assess guidance, navigation, control and software engineering 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, Space Transfer Vehicle (STV), Manned Maneuvering Unit (MMU), free flyers, aeromaneuvering planetary and earth return vehicles and the Space Station. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. Software engineering areas of research include: new models, methodologies, and paradigms to advance the life cycle engineering of software; productivity tools for software development and maintenance; development and maintenance of distributed information systems; software fault tolerance and systems survivability; 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. The approach used will be to conduct studies, analyses, and trade-off studies to define hardware and software requirements.

Human Support Research and Technology

W91-70088 **(21) 506-71**
Ames Research Center, Moffett Field, CA.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
R. K. Dismukes 415-604-5729
(505-64-00; 199-06-12)

The overall objective of this RTOP is to develop a research and technology base in life support systems, extravehicular activity (EVA) technology, and crew design. The objective of the advanced life support activities 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 and further the development of portable life support systems necessary for extravehicular activity. Models of physical/chemical life support process technologies will be used in evaluating system performance, guiding experimental research and development programs, designing complex integrated closed loop life support systems, and troubleshooting operating systems. Crew station design technology has as its goal the development of a technology base for advanced crew stations, operator interfaces, crew support systems for information management, and crew interfaces for the monitoring and control of autonomous subsystems. Research will be conducted in laboratories, simulators, testbeds, and operational settings at various NASA Centers. Demonstration of interfaces and crewstation technology will be conducted in engineering testbeds at ARC and in operational settings at JSC and other NASA Centers.

W91-70089 **(72) 506-71**
Lyndon B. Johnson Space Center, Houston, TX.
HUMAN SUPPORT 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 human-computer 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 activity (EVA) 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 0-G suit technology include modeling human performance in EVA suits and developing equipment to increase the productivity of EVA. The tasks for crewstation design technology cover a range of activities from examining human-computer interface displays and controls to collecting and analyzing the experiences of humans in space. The emphasis is on producing requirements and guidelines to enhance new spacecraft design.

Interdisciplinary Technology

W91-70090 **(10) 506-90**
National Aeronautics and Space Administration, Washington, DC.
INTERDISCIPLINARY TECHNOLOGY
Glenn C. Fuller 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 Technology Experiments

In-Space Experiments

W91-70091 **(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 Space Transportation System (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 radiation dosage 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) has been awarded the contract to design and fabricate the flight emulsion chamber box subsequent to NASA Headquarters Peer Review Team approval.

W91-70092 **(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 development of in-space technology experiments to flight evaluate and validate advanced technologies for future space systems. This RTOP supports Phase C/D (flight development). 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 two NASA flight projects: SAMPIE (Solar Array Module Plasma Interaction Experiment), and TEST (Thermal Energy Storage Technology); and one I/U flight project: the Boeing TPCE (Tank Pressure Control Experiment).

W91-70093 **(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. The program currently includes experiments dealing with thermal management, fluid dynamics, contamination modeling 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.

W91-70094 **(72) 589-01**
Lyndon B. Johnson Space Center, Houston, TX.
IN-SPACE EXPERIMENTS
K. E. Henderson 713-283-5307

The Debris Collision Warning Sensor (DCWS) will be a flight experiment. Debris in low Earth orbit (LEO) constitutes an increasing hazard to manned and unmanned spacecraft and astronauts on EVA. For the Space Station, relatively large debris pieces constitute 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 mm 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 sets leading to an improved understanding of the mechanisms, processes, and molecular transition states responsible for glow. This technology will enable the development of methods and procedures to limit the undesired effects of glow on sensitive scientific experiments conducted during future NASA missions.

W91-70095 **(23) 589-01**
Langley Research Center, Hampton, VA.
IN-SPACE EXPERIMENTS
Frank Allario 804-864-6027
(506-48-00)

The technical objectives of this program are to complete the design and to conduct the development of the Mid-Deck 0-Gravity Dynamics Experiment (MODE), to conduct the Development of the Mid-Deck Active Control Experiment (MACE), to carry out breadboard studies and design activities for the Stanford University/NASA Laser In-Space Technology Experiment (SUNLITE), and obtain materials, systems, ionizing radiation, and micrometeoroid and debris data from Long Duration Exposure Facility (LDEF) and contribute these data to LDEF data bases which include information from studies performed by principal investigators as well as the Special Investigation Groups (SIG's). A contracted effort will be conducted to develop the hardware and associated procedures for performing MODE. A contracted effort will be conducted to develop the hardware and associated procedures for performing MACE. In-house and contracted studies will be directed at a breadboard of critical components of SUNLITE and the development of a laser assembly specification.

Civil Space Technology Initiative Program

Operations

W91-70096 **(72) 590-11**
Lyndon B. Johnson Space Center, Houston, TX.
TELEROBOTICS
C. R. Price 713-483-1523

The objective of the teleoperations 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 robotics program element is to perform research in advanced robotics regarding fault tolerant manipulators as well as developing techniques for automated assembly and ORU replacement. The primary goal is to develop an advanced precision, dexterous, 8 DOF 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.

W91-70097 **(51) 590-11**
Goddard Space Flight Center, Greenbelt, MD.
TELEROBOTICS
Charles E. Campbell, Jr. 301-286-9017

Capability is to be developed for autonomous robotic servicing of earth orbiting satellites utilizing task planning and decomposition, database assisted path planning, machine vision directed path monitoring, and low level robotic control algorithms. Active force/torque compliance will be used with a Stewart Platform mounted to a T3 robot to perform peg-in-hole and bolting operations on Hubble Space Telescope module mockups. The controls for the Stewart Platform are being developed at Catholic University. Communications between software modules is provided by a virtual blackboard on an Ethernet backbone. The database is composed of CAD data augmented with connectivity/orientation information to support task planning with vision-updated data supplementing positioning. Path planning will use the Purdue University slide-jump method coupled with optimal control approaches to produce plans for most robotic motions, with a Stanford planner taking into account situations requiring high degree of freedom planning.

W91-70098 **(21) 590-11**
Ames Research Center, Moffett Field, CA.
TELEROBOTICS
H. Lum, Jr. 415-604-6544
(590-12-00)

The objective is to develop and test integrated knowledge-based systems including real-time control and human/machine interfaces for mobile 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 object-level control and operator interfaces. 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: object-level control and operator interfacing, cooperative manipulation; simultaneous control of a quick minimanipulator and the very flexible arm that carries it; free flying space robot navigation and locomotion; multiple-robot team cooperation; control of very flexible, multi-link manipulators; and load-adaptive control in each of the above. A research effort has also been established with Stanford University Department of Computer Science to integrate the Artificial Intelligence research with the robotics research with emphasis on the development of intelligent cooperating robots.

W91-70099 **(62) 590-11**
Marshall Space Flight Center, Huntsville, AL.
TELEROBOTICS
J. B. Haussler 205-544-1762

The overall objective of this RTOP is the implementation and integration of advanced telerobotic controls for complex dynamic orbital operations, such as the Tumbling Satellite Retrieval program from either a small free flyer or a semi-flexible boom (e.g., the Remote Manipulator System). This RTOP will focus on the application and evaluation of emerging and proven technologies and control architectures in real time, dynamic test bed demonstrations for near-term Low Earth Orbit programs such as Space Station Freedom, Shuttle-C, and Tumbling Satellite Retrieval. The first proposed effort will take test hardware developed under a program development study contract and add an integrated control system with sensors to perform complex control functions in either a telerobotic or supervised autonomous mode. This effort offloads the remote operator, allows faster in situ response time, and expedites system development.

W91-70100 **(76) 590-11**
John F. Kennedy Space Center, Cocoa Beach, FL.
TELEROBOTICS
Eric L. Rhodes 407-867-2780

The objective of this RTOP is to demonstrate the use of robotics technologies to solve specific problems in NASA launch vehicle and payload processing operations at KSC. The primary project goal is to introduce, within two to three years, robotic applications into those areas that will improve operations efficiency as well as increase safety, quality, and reliability. This goal will be accomplished by implementing the results of FY-90 studies to focus the appropriate technology into realistic operations areas which are supported by the user. Production qualified prototype hardware will be developed to demonstrate feasibility to the user community. This hardware will be sufficiently robust to enable the user to develop confidence in using robots around space hardware. A secondary goal is to demonstrate, on the ground, the feasibility and robustness of robotics that may be used in space. This work will be carried out by both in-house and contracted companies, universities, and others as needed. Tasks will be directed by the KSC Advanced Projects Office and will be conducted by engineers in coordination with personnel from: vehicle operations, payload operations, facility operations, other NASA centers, University communities, and contractors. The designs selected are the ones analyzed as the most appropriate for high payoff and initial project success. The projects will minimize technical risk by maximizing use of existing robust components. This will improve the efficiency and reliability, and reduce costs of the current KSC launch vehicle and payload processing tasks. In addition, the selected concepts are applicable to development of more advanced autonomous systems for both Space Station and future launch vehicle ground operations.

W91-70101 **(55) 590-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TELEROBOTICS
Charles R. Weisbin 818-354-2013
(488-90-00; 486-86-00; 906-30-00)

The general objective of this RTOP is to develop a base of system technologies to provide the capabilities of performing a wide variety of manipulation tasks in space, and to demonstrate to prospective users the availability of that technology base. Example applications are space construction, satellite servicing, solar system exploration, space station, platform maintenance and repair, and support of scientific experiments. The system technology to be developed and demonstrated spans the range from purely manned teleoperation to automated servicing under manned supervision, and includes the integration of diverse component and subsystem technologies such as advanced teleoperators, human/machine interfaces, manipulation and mobility, autonomous planning and reasoning, machine vision, and multi-sensor fusion. The program is focussed about two system level paradigms: computer-assisted manned teleoperation (the Advanced Teleoperation paradigm) and supervised autonomous systems (the Ground-Controlled Remote Manipulation (GCRM) paradigm). Under the aegis of these paradigms, system capabilities will be demonstrated to meet the specific needs of real space missions. For the Advanced Teleoperation paradigm, the well understood Solar Max Repair Mission will be used to focus and evaluate the technology advancements. Similarly, servicing a Great Observatory, like AXAF, and exchanging a Space Station ORU will be used to focus and evaluate the GCRM paradigm.

W91-70102 **(10) 590-11**
National Aeronautics and Space Administration, Washington, DC.
TELEROBOTICS
Lee B. Holcomb 202-453-2747

The purpose of this RTOP is to conduct space operations research with particular emphasis on human capabilities assisted by various levels of automation. The research will be conducted by developing and testing a beam assembly teleoperator (BAT) for use in neutral buoyancy tests. Also tests will be conducted of closed cabin free flyers, head up displays for control of maneuvering units, simulation of telepresence technology, investigation of the human function in supervisory control and the investigation of expert system for task assignment and housekeeping aboard a space station. This work will be carried out under a grant to the University of Maryland. A second task is to provide support to the automation and robotics program.

W91-70103 **(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. Current plans are to investigate cooperative human/machine control of compound and redundant 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; and to develop and apply sensing, planning, and control methods to enable realistic robotic tasks under remote supervision.

W91-70104 **(62) 590-12**
Marshall Space Flight Center, Huntsville, AL.
ARTIFICIAL INTELLIGENCE
J. B. Haussler 205-544-1762

The Space Station Module/Power Management and Distribution (SSM/PMAD) task consists of three expert systems that must cooperate to control a single subsystem. These expert systems need to '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 objective may be partially accomplished with smart front ends and interfaces. A blackboard architecture, called the Knowledge Management Design (KNOMAD) System, has been implemented as one approach to the problem. A related issue to the multiple interactive expert systems is that of having the expert systems closely interact with the conventional software. NASA programs involving artificial intelligence (AI) will, in many cases, require the expert system(s) to be closely coupled to embedded conventional software programs. The overall objective of the Hubble Space Telescope Design Engineering Knowledge base (HSTDEK) project is to enable major NASA projects to capture the design/engineering expertise they have acquired during the development of their systems in knowledge base(s) capable of supporting multiple applications. In order to accomplish this, current knowledge engineering technology must be extended in several areas, the new technology must be validated, and a mechanism established for transferring it to users within NASA. The key objectives for this phase of the project are (1) complete development of the HST vehicle analysis systems, (2) transfer this technology to other NASA efforts, targeting follow-on HST mission phases, Advanced X-ray Astrophysics Facility, and avionics systems test facilities, and (3) continued development of in-house knowledge engineering capabilities for NASA to apply these tools and support their validation.

W91-70105 **(55) 590-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARTIFICIAL INTELLIGENCE
Richard J. Doyle 818-354-6476

The objectives are to apply and extend mature AI based solutions in the areas of scheduling, monitoring, diagnosis and data analysis, and demonstrate technological readiness for addressing current mission operations and scientific data analysis needs; and to push the state-of-the-art in AI in scheduling, planning, and model-based reasoning to address long-term JPL and NASA needs. The approach consists of (1) Mission Operations Assistance, comprising the Planner Evaluation Techniques task, which will produce a framework for classifying planning problems and solutions; the Ground Data Systems Automation Task which will develop and demonstrate monitoring and control technology for ground data systems in Space Flight Operations and Deep Space Network, and the Space Operations Mission Planner Task, which will provide capabilities for generating schedules for over-subscribed domains and modifying them in real-time to accommodate unanticipated events and changes in resource configuration. (2) Data Analysis Techniques, which consist of the Scientific Analysis Assistant Task using AI techniques to unify data access, management, analysis and graphic presentation capabilities in a set of software tools to support scientists analyzing large volumes of data. (3) Autonomous control, which consists of the selective processing in monitoring task which will generate and evaluate methods of monitoring systems where complexity and resource limitations preclude exhaustive verification.

W91-70106 **(76) 590-12**
John F. Kennedy Space Center, Cocoa Beach, FL.
ARTIFICIAL INTELLIGENCE
A. Heard 407-867-2780

The objective of this RTOP is to provide technology development support for application of knowledge-based systems to STS Processing at KSC. The project goal is to emulate the existing distributed processing system used for the KSC Launch Processing System (LPS) by demonstrating a distributed set of knowledge-based systems cooperating to provide system analysis, fault monitoring, diagnosis, and task planning and scheduling support for STS processing operations. This goal will be accomplished by production of a distributed architecture shell allowing integration of independently developed intelligent applications into a unified intelligent operations support tool sharing resources such as real-time data and knowledge base access. Knowledge based systems to be included in this environment are Test Engineer (KATE) advisory system shell which will be refined to support additional vehicle subsystems. This resulting demonstration environment, an Expert System for Operations Distributed Users (EXODUS), will facilitate deployment of intelligent systems for KSC operations by streamlining data interface requirements, allowing incremental application additions and offering a low risk vehicle for validation and assessment of value-added automation enhancements offered by the various knowledge-based systems. Incorporation of project goals should improve the efficiency and reliability and reduce costs of the current KSC launch processing tasks to better accommodate planned launch rate increases. In addition, project developed concepts are applicable to development of autonomous systems for both Space Station and future launch vehicle ground and on-board systems.

W91-70107 **(21) 590-12**
Ames Research Center, Moffett Field, CA.
ARTIFICIAL INTELLIGENCE
H. Lum, Jr. 415-604-6544
(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. AI applications to these missions fall into four basic categories: intelligent assistance for humans involved in ground and space-based mission operations; tools and techniques to aid in the analysis of scientific and engineering data; autonomous, on-board, fault diagnosis, correction, and control of spacecraft systems; and, capture, integration, and preservation of life-cycle knowledge. 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, and design of and reasoning about large-scale physical 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. 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).

W91-70108 **(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 and demonstrate the concept of an Intelligent Control Center (ICC). This testbed will incorporate multiple knowledge-based ground operations system components which operate in a coordinated and cooperative fashion to achieve operational system objectives.

W91-70109 **(72) 590-12**
Lyndon B. Johnson Space Center, Houston, TX.
ARTIFICIAL INTELLIGENCE
K. J. Healey 713-483-4776

The objectives of this RTOP are to continue the appropriate application of artificial intelligence in ground operations centers, 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 link the systems together to form a distributed cooperative real-time expert system. 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.

W91-70110 **(22) 590-12**
Lewis Research Center, Cleveland, OH.
ARTIFICIAL INTELLIGENCE
H. W. Brandhorst 216-433-6149
(488-51-03)

The objective is to provide technology development support for application of knowledge based systems (KBS) to the Space Station Freedom Electrical Power Systems (SSFEPS) and other complex manned systems. 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) expert system, consisting of fault management and power/energy scheduler software along with appropriate control interfaces, and to demonstrate its operation on appropriate power testbed facilities. 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.

W91-70111 **(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 SP-100 GES 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 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.

W91-70112 **(55) 590-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH CAPACITY POWER
C. P. Bankston 818-354-6793

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 major activities focus on 'doping' techniques with silicon-germanium materials utilizing hot pressed, polycrystalline and single crystal approaches, coupled with theoretical modeling.

W91-70113 **(55) 590-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROLS/STRUCTURES INTERACTIONS (CSI)
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 is coordinated with the other participating NASA centers and concentrates on the CSI technology area of micro-precision controlled structures. Focus missions will be used to demonstrate the advantages of applying CSI technology in terms of reduced development costs and improved operational performance. 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.

W91-70114 **(62) 590-14**
Marshall Space Flight Center, Huntsville, AL.
CONTROLS/STRUCTURES INTERACTIONS (CSI)
J. F. MacPherson 205-544-5936

The objective of this technology program is to develop a Ground Test Facility (GTF) to perform the advanced development studies for the Control and Structures Experiment in Space (CASES) program. The CASES flight experiment will demonstrate the flight readiness of several key Control Structure Interactions (CSI) methodologies in the early 1990's, thereby enabling future NASA science missions which will require CSI technology to proceed on course. The approach towards CASES will be to develop a prototype GTF under this RTOP in support of the CASES definition, design, and development phases. To minimize technical and cost risks, the flight proven OAST-1 test structure will be utilized in CASES. The definition phase (Phase B) began in FY-89. 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.

W91-70115 **(23) 590-14**
Langley Research Center, Hampton, VA.
CONTROLS/STRUCTURES INTERACTIONS (CSI)
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 to 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/ground tests.

Transportation

W91-70116 **(23) 590-21**
Langley Research Center, Hampton, VA.
EARTH TO ORBIT
W. R. Hook 804-864-6055

The objective is to provide resources for system studies for Earth-to-orbit vehicles to assess the impact of propulsion technology on overall vehicle performance and cost.

W91-70117 **(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. LOX/hydrocarbon propellant systems and components will receive attention in order to provide the technology base necessary to design and evaluate their impact on future Earth-to-orbit vehicle size, mass, and cost. Although focused on reusable manned vehicles, the resulting technology advancements and design and development tools will be applicable to a wide range of future engine design options, including expendable or partially reusable cargo delivery vehicles as well as growth versions and derivatives of the space shuttle.

W91-70118 **(62) 590-21**
Marshall Space Flight Center, Huntsville, AL.
EARTH TO ORBIT PROPULSION
J. L. Moses 205-544-1747

The earth-to-orbit propulsion technology base will be extended and developed in support of current and future space transportation systems. The technology described herein encompasses oxygen/hydrogen, oxygen/hydrocarbon propulsion as well as hybrid propulsion technology (hybrid propulsion consists of a solid fuel grain and a liquid oxidizer) and is directed at enhancing engine life, performance and operability. The activity is divided into three categories: O2/H2 technology acquisition, O2/H2 technology validation, and hybrid propulsion. 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 test bed. The hybrid activity will focus on component and subscale activities through analyses, development of sealing laws, processes and procedures. These tools will be used to verify successive levels of scale and maturity of the hybrid concept.

Science

(62) 590-31

W91-70119
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.

(55) 590-31

W91-70120
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE SENSOR TECHNOLOGY
V. Sarohia 818-354-6758

The objective is to develop enabling sensor technologies for future NASA space missions such as SIRTF (Space Infrared Telescope Facility), Earth Observing System (EOS), SMILS, or LDR (Large Deployable Reflectors). One of the goals is to develop a space qualifiable submillimeter heterodyne receiver. The enabling components are: mixer elements, local oscillators, and tuning and embedding structures operating in the frequency range 300 to 3000 GHz. The mixer element for astronomy applications is a Superconductor Insulator Superconductor (SIS) tunnel junction based on the niobium and niobium nitride materials systems. Single elements and arrays of elements will be developed. Planar mixers using gallium arsenide will be developed for the EOS Microwave Limb Sounder (MLS). The goal of the local oscillator element is to develop devices and demonstrate performance in the THz range. The detector sensor program focuses on infrared detectors and will develop detectors based on silicon compatible material systems and novel device structures with response to 17 microns; quantum well detectors out to 17 micron response at 65 K and study the responsivity, noise mechanisms, dark current, detectivity, spectral response, and temperature dependence of the above parameters; space qualifiable, high sensitivity germanium blocked impurity band (GeBIB) detector arrays for far infrared (30 to 200 microns) instruments; and a high sensitivity electron tunneling position infrared sensor for detection at room temperature.

(23) 590-31

W91-70121
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.

(21) 590-31

W91-70122
Ames Research Center, Moffett Field, CA.
SCIENCE SENSOR TECHNOLOGY
C. R. McCreight 415-604-6549
(506-59-00)

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), Submillimeter Moderate Mission (SMMM), 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.

(51) 590-31

W91-70123
Goddard Space Flight Center, Greenbelt, MD.
SCIENCE SENSOR TECHNOLOGY
Henry H. Plotkin 301-286-6185
(506-55-11)

Sensor technology is being developed in the areas of Lidar and Cooler Systems. Advanced electro-optics and laser technologies are being developed for spaceborne laser ranging and altimetry earth science applications on EOS. The Geoscience Laser Ranging System (GLRS) is being designed to provide geoscience measurements requiring extremely accurate geodetic observations from a spacecraft. The GLRS facility instrument uses state-of-the-art picosecond pulse lasers to remotely sense the position of cooperative retroreflector targets on the earth's surface. The instrument employs the technique of pulse time-of-flight measurement to determine the distance between the satellite and target. In the altimetric mode, relative height determinations will be obtained with a nadir-looking Q-switched, nanosecond pulse solid state laser transmitter and range-gated receiver. 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.

(51) 590-32

W91-70124
Goddard Space Flight Center, Greenbelt, MD.
HIGH RATE/CAPACITY DATA SYSTEM
John T. Dalton 301-286-8623

The objective is to develop 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. The CHRPS capabilities will be adaptable to the needs of different instruments and missions by reconfiguring in real time to adapt to changes in the operating environment. The architecture will adapt to support a range of high data rate imaging missions and will support evaluation of higher levels of onboard data compression, analysis, and instrument control through development of onboard processor and storage technology. 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 instrument interface to communication link transmitters and receivers. This includes all formatting, coding, buffering, processing, editing, storage, and multiplexing required by complex heterogeneous payloads operating from ten to hundreds of megabits per second. Integration of technology components from other centers into a testbed demonstration focused on compression and management of data from EOS high rate sensors is included.

(23) 590-32

W91-70125
Langley Research Center, Hampton, VA.
HIGH RATE/CAPACITY DATA SYSTEMS
Frank Allario 804-864-6027
(506-59-00; 505-64-00)

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.

W91-70126

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **(55) 590-32**

HIGH RATE/CAPACITY DATA SYSTEMS

Daniel E. Erickson 818-354-1656

(506-59-00)

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 OAET program plan. 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 multicomputer, 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; (3) an autocorrelation spectrometer suitable for use in spaceborne mm wave and submm wave radiometers; and (4) a magnetoresistive tape recorder head which will demonstrate the technology to improve record rates and storage capacity by an order of magnitude. 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.

W91-70127

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **(55) 590-33**

PRECISION SEGMENTED REFLECTORS

David H. Lehman 818-354-3202

The objective is to develop the technology for large lightweight precision reflectors. This is the JPL portion of a joint effort with LaRC to support the development of space-borne reflectors technology. This program is directed toward providing surfaces with the precision required for the Far Infrared Region (wavelengths greater than 75 microns) which will then be followed by progress toward shorter wavelengths. The long term goal is to develop a technology base to enable future missions that are expected to use large, lightweight, low-cost reflectors. To date precision 1-meter composite panel (at ambient), control/sensing components, and precision structures have been developed. This program will develop 1 meter composite panels that operate in the simulated space environment, the panel control/sensing system necessary to maintain an accurate figure and test the panels on a representative structure. Technology will be integrated into a test bed demonstration of an actively controlled, segmented reflector that will be operated in two years (1992). It will provide a means of validating the technology and a test bed for future technology developments. Alternate panel construction materials will be researched 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 on a representative structure will be developed.

W91-70128

Langley Research Center, Hampton, VA. **(23) 590-33**

PRECISION SEGMENTED REFLECTORS

C. P. Blankenship 804-864-6005

The research includes development, fabrication, and testing programs in structures and materials with emphasis on advanced composite materials and coatings and 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.

Aeroassist Flight Experiment

W91-70129

Langley Research Center, Hampton, VA. **(23) 592-01**

LUNAR-TO-EARTH 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 validated analysis. The instrumentation will be integrated into the Aeroassist Flight Experiment (AFE) spacecraft and the flight will be conducted to maximize the science return such that technology needs for computational fluid dynamics code validation (radiative heating, wall catalysis, alternate thermal protection material, and base flow) can be satisfied and the aerodynamic and control phenomena of this generic shape can be assessed.

W91-70130

Ames Research Center, Moffett Field, CA. **(21) 592-01**

LUNAR-TO-EARTH AEROBRAKING

A. J. Wilhelmi 415-604-5372

The overall objective of this effort is to provide 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 will only penetrate the upper regions of the Earth's atmosphere at or near geosynchronous return velocities, the AFE will provide design environments that cannot be simulated in ground facilities or determined through analysis. It is necessary, therefore, to obtain critical aerodynamic and aerothermodynamic environments for adequate flight control and thermal protection system design 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 and experiment development. Langley Research Center (LaRC) and Ames Research Center (ARC) are responsible for development of several major experiments. This RTOP provides program support for the ARC AFE program.

W91-70131 **(62) 592-01**
Marshall Space Flight Center, Huntsville, AL.
LUNAR-TO-EARTH 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 an aerodynamic braking maneuver will only penetrate the upper regions of the Earth's atmosphere at or near geosynchronous return velocities, the AFE will provide design environments that cannot be simulated in ground facilities or determined through analysis. It is necessary, therefore, to obtain critical aerodynamic and aerothermodynamic environments for adequate flight control and thermal protection 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 with Langley Research Center. Ames Research Center is responsible for development of other major experiments.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

Planetary Geology R&A

W91-70132 **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.

W91-70133 **151-01-60**
Ames Research Center, Moffett Field, CA.
SOLAR SYSTEM STUDIES
P. Cassen 415-604-5597

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 and other solar system bodies. 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, and to construct self-consistent mathematical models of planetary processes and structures. Problem areas that are being addressed include: the dynamics and evolution of the solar nebula and protostellar disks in general; the nature of primitive bodies such as comet nuclei; the formation of planets and satellites; the structure and origin of planetary rings; and the interaction of planetary atmospheres with surfaces.

W91-70134 **151-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETOLOGY
S. M. Baloga 818-354-2039

This RTOP is a collection of individual planetary geology and geophysics tasks to improve 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.

W91-70135 **151-02-50**
Goddard Space Flight Center, Greenbelt, MD.
EARLY MARS: IMPACT BASINS, CRUSTAL DICHOTOMY, VOLCANIC RESURFACING
Herbert Frey 301-286-5450

The objectives of this RTOP are to determine the nature of the crustal dichotomy on Mars, the role played by major impacts in the evolution of this dichotomy, and the relationship of impacts and the crustal dichotomy to major volcanic resurfacing in early Martian history. These remain among the fundamental unanswered questions in Martian geological evolution, and are relevant to comparative planetary understanding of planetary lithospheric evolution. The approach of this RTOP is to: (1) extend the search for evidence of large impact basins, with emphasis on the cratered southern highlands and especially the south polar region where our current inventory shows an exceptionally low number of large impact basins; (2) map in detail the multiple ring structure of South Polar Basin and its relation to ridged plains volcanism in this area; (3) undertake a detailed structural and stratigraphic study of the crustal dichotomy boundary in Acidalia, one of the few places in western Mars where it is well-expressed, and compare this with the boundary further east in Ismenius Lacus and Casius; (4) assess whether the evolution of this boundary was mostly influenced by endogenic or exogenic events and how this constrains the origin of the crustal dichotomy as a whole; and (5) determine if additional outcrops of Nplr ridged plains are truly Noachian in age, or Hesperian-age flows so thin that Noachian-age craters show through.

W91-70136 **151-88-00**
Ames Research Center, Moffett Field, CA.
IMPACT CATASTROPHISM ON THE TERRESTRIAL PLANETS
G. C. Carle 415-604-5765

The objective of this research is to develop an understanding of the effects of catastrophic impacts on planetary bodies and their processes during the span of geologic history. The approach of the RTOP is to study the effect of impacts on planetary bodies in order to evaluate the role impacts played in shaping the biota and geologic evolution of the terrestrial planets. It is apparent that what is first needed is a complete theory for the probability of occurrence of rare catastrophic impacts. By developing such a theory, important questions can be addressed concerning a variety of geochemical and biologic questions involving the early history of the terrestrial planets.

Planetary Materials

W91-70137 **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.

W91-70138 **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.

W91-70139 **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) to determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) to 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.

W91-70140 **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.

W91-70141 **152-13-60**
Ames Research Center, Moffett Field, CA.
PLANETARY MATERIALS-CARBONACEOUS METEORITES AND COMETARY ICE ANALOGS
S. Chang 415-604-5733

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 and laboratory analogs of cometary ices. The approach taken to meet this objective focuses on the chemical and mineralogical-petrographic analyses of meteorites and laboratory study of astrophysical ices. The abundance, isotopic composition, and distribution of selected elements are measured; and the occurrence and distribution of various mineral phases are determined in meteorites. 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. The structure, morphology and composition of cometary ice analogs are determined in laboratory studies conducted under simulated astrophysical conditions. Correlations between laboratory observations and astronomical observations of interstellar and cometary ices will be sought in order to understand the nature and origins of the natural materials.

W91-70142 **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.

W91-70143 **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.

W91-70144 **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.

W91-70145 **152-17-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY MATERIALS AND GEOCHEMISTRY
S. M. Baloga 818-354-2039

The objective of this RTOP is to further the understanding of the solar system by studying the electromagnetic radiation reflected from simulated and candidate planetary materials. 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. The approach is an experimental study of the characteristics of planetary materials with inferences of direct relevance to existing NASA missions to asteroids and icy satellites.

W91-70146 **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. A system will be constructed and tested 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. The magnetic properties of the Fe-Ni system and the magnetic record contained in meteoritic materials will also be characterized. 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. Particle size, composition, crystal structure and morphology will be determined. If the particles produced during the nucleation experiment are uniform, then the end of a nucleation experiment will constitute the beginning of a particle coagulation experiment. Changes in the particle size distribution due to aggregation will be monitored via light scattering and extinction measurements. Because of the short time available in 0 gravity (t 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. Magnetic characterization of materials will occur both on the ground and aboard the KC-135 aircraft.

W91-70147 **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 to 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.

W91-70148 **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 cost required to operate common laboratory and computer facilities. This plan also provides inhouse laboratory maintenance for the visiting scientist programs of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.). A significant element of this RTOP is an annually updated plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefiting NASA and other agency programs. The PMGP is asked to support about 20 percent of the modernization.

Planetary Atmospheres R&A

W91-70149 **154-01-80**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY ATMOSPHERES PROGRAM
J. F. Appleby 818-354-3943

This group of interrelated research tasks addresses the chemical, physical, and dynamical properties of the atmospheres of planets, satellites, and comets. These investigations examine the atmospheric and ionospheric aspects of planetary objects (other than Earth), including studies of atmospheric chemistry; comparative planetology; atmospheric evolution; radiation balance, thermal structure, molecular composition, radiative-dynamical coupling, and spatial and temporal variations; clouds, dust, aerosols, and the horizontal and vertical distributions of these materials; climate and climate history; atmospheric wave and wind fields, mass transport, and wave-mean flow interactions; and the composition and dynamics of cometary comae and related dust phenomena. The basic objective of this research is to determine from observational data, laboratory experiments, and theoretical considerations the present characteristics and evolution of planetary atmospheres. A major objective is to carry out interpretive analysis of observational results obtained by unmanned spacecraft missions and ground-based telescopic observations of the gaseous envelopes of planetary objects throughout the solar system and to derive new missions and new observations to further our knowledge of the solar system. This RTOP also supports: (1) IR spectroscopic and high-energy laboratory measurements for planetary atmospheres research; (2) visiting distinguished scientists visits to JPL; and (3) services of a detailee to the Planetary Atmospheres Program Office at NASA Headquarters.

W91-70150 **154-10-80**
Ames Research Center, Moffett Field, CA.
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-604-5530
(196-88-00)

The objective 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 as follows. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Voyager, or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

W91-70151 **154-20-80**
Ames Research Center, Moffett Field, CA.
DYNAMICS OF PLANETARY ATMOSPHERES
R. E. Young 415-604-5521

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.

W91-70152 **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. Derivation of optical and dynamical properties of the Martian atmosphere from Mariner 9 infrared spectra, and Mariner 9 and Viking orbiter images is addressed. The determination of the haze production and investigation of dynamics in Saturn's and Titan's stratosphere from photochemical models is also addressed.

W91-70153 **154-30-80**
Ames Research Center, Moffett Field, CA.
PLANETARY CLOUDS PARTICULATES AND ICES
O. B. Toon 415-604-5971

Goals of this program are: (1) to determine the nature and properties of clouds and aerosols on Mars, Titan, and the outer planets based on observational and theoretical considerations; (2) to determine the physical and chemical processes responsible for the cloud structures observed on Mars, Titan, and the outer planets; (3) to provide comparisons between terrestrial and planetary clouds; and (4) 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 clouds on Mars and is being readied to investigate the methane clouds on Uranus and Neptune and the other outer planets. Imaging and other observations are being used to constrain models of radiative transfer in a planetary atmosphere to determine the vertical structure of clouds on Uranus and Neptune.

W91-70154 **154-60-80**
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF MOIST CONVECTION ON THE OUTER PLANETS
C. R. Stoker 415-604-6490

The objective of this RTOP is to understand the physical processes associated with moist convection on the outer planets. The effects of cloud microphysical processes on bulk cloud structure in the atmospheres of the outer planets Jupiter, Saturn, Uranus, and Neptune; the manner in which cloud precipitation formation and mass loading of updrafts by condensates affects the dynamics of convective clouds; and the conditions required to initiate moist convection on the outer planets will be investigated. The approach of this RTOP is to study the effect of moisture variations on cloud and atmospheric dynamics and of condensation and cloud microphysical processes on cloud dynamics and on the vertical structure of clouds in the atmospheres of the outer planets. Numerical models are being developed for moist convective clouds and procedures are being incorporated to study the formation and growth of condensate clouds in the atmospheres of the outer planets.

W91-70155 **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, and comparative planetary atmospheres.

154-75-80

W91-70156
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 physicochemical 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 (FTIR) and a mass spectrometer. Formation and properties of porous, low density ice/dust aggregates are measured. Theoretical models of the nucleus are developed.

154-90-80

W91-70157
Ames Research Center, Moffett Field, CA.
PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS
W. J. Borucki 415-604-6492

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. An analysis of Voyager spacecraft images shows that Jovian lightning characteristics are dissimilar to those of terrestrial lightning. Further efforts to characterize lightning activity and characteristics on other planets are underway. 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.

154-95-80

W91-70158
Ames Research Center, Moffett Field, CA.
MARS 3-D GLOBAL CIRCULATION MODEL
R. M. Haberle 415-604-5491

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

155-01-20

W91-70159
Lyndon B. Johnson Space Center, Houston, TX.
MARS DATA ANALYSIS PROGRAM: MARS SURFACE AND ATMOSPHERE THROUGH TIME
D. P. Blanchard 713-483-5151

The general objective is to better characterize the different reservoirs of volatile elements on Mars and their roles in Martian geological processes. The specific objective is to perform experiments to investigate the origin of the shergottite meteorites and their associated volatiles. Experiments will be performed to determine the liquidus temperature for the groundmass composition of EETA79001A, arguably one of the more primitive shergottite meteorites. Controlled cooling experiments at appropriate oxygen fugacities will then be performed to determine how this liquid composition changes as the system fractionally crystallizes. Equilibrium experiments will also be used to define the cotectic boundaries of the shergottite compositional system. These experimental compositions will then be compared to the compositions of the shergottites themselves. These experiments will result in a better understanding of the shergottites and their volatile element signatures.

155-01-60

W91-70160
Ames Research Center, Moffett Field, CA.
MARS SURFACE AND ATMOSPHERE STUDIES
R. M. Haberle 415-604-5491

The objective of this research is to better understand: (1) the nature and variability of the Martian planetary boundary layer; (2) the ability of water molecules on Mars to adsorb onto soil particles in the presence of a carbon dioxide background gas; and (3) the radiative properties of suspended dust particles in the Martian atmosphere. This research is stimulated by NASA's ongoing planetary exploration program, and the President's recent Space Exploration Initiative. The approach of this effort involves observational, theoretical, and experimental analyses. The observational approach involves further reduction of Viking and Mariner 9 data. The theoretical approach involves use of high speed computer codes to solve complex radiative transfer and fluid dynamical problems. The experimental approach will create a near Mars-like environment to develop new insight into otherwise intractable problems. Each of these approaches makes effective use of the computational and laboratory facilities at Ames.

W91-70161
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **155-50-70**
MARS SURFACE AND ATMOSPHERE THROUGH TIME
S. M. Baloga 818-354-2039

The objective of this RTOP is to further the understanding of the interaction between the atmosphere and the physical and geologic processes that operated on the surface of Mars during its evolution to current conditions. This research will directly improve understanding of the atmosphere of Mars and the relationship between dust storms and atmospheric opacity. This research directly supports planned NASA missions to Mars.

W91-70162
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **155-88-00**
PLANETARY DATA SYSTEM
J. T. Renfrow 818-354-6347
(656-61-06)

The objectives are to operate an integrated Planetary Data System (PDS) consisting of a Central Node, six Discipline Nodes, and a Navigation Ancillary Information Facility (NAIF) support node, to complete the development of detailed mission interfaces with the active flight missions, to ingest data from the Voyager Project and the early phases of the Magellan project, and to restore data sets from past missions. The Central Node will continue the operation of the PDS Catalog and Data Order System. The Discipline Nodes will support the data ingestion and distribution of science data and will provide expert help to the planetary science user community. The data storage technologies and the generic mission interface approaches being funded under the allied Code SC RTOPs will be integrated into the operational approach of the PDS. The system engineering of the entire PDS system, including the components at the Central Node and Discipline Nodes, will be carried out and the plans for future architectural enhancements will be developed and integrated into the PDS operations. The integration of the Discipline Nodes into the operational PDS will be completed and the Nodes will assume a completely functional status. Detailed engineering of the data archive and transfer process with each of the active missions (Magellan, Mars Observer, and Galileo) will be performed.

Planetary Instrument Definition

W91-70163
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **157-01-70**
LOW PHASE NOISE MICROWAVE OSCILLATOR
G. J. Dick 818-354-6393

The primary objective of this research is to develop and test a microwave oscillator with ultralow phase noise suitable for application on board spacecraft, in support of radio science experiments. In particular, close-in phase noise with offset frequencies from 1 Hz to 1000 Hz will be reduced as much as 25 dB below that presently attainable. The oscillator is based on a technology consisting of a cooled sapphire whispering gallery mode resonator, and will operate in the temperature range achievable by means of radiative and thermoelectric cooling. Evaluation of the oscillator will provide the basis for the development of an instrument to be deployed on board spacecraft for future missions. Two oscillators are being constructed, one to act as a reference for the other, there being no other available frequency source with sufficiently low phase noise for testing. A STALO (STAbilized Local Oscillator) design was chosen as providing the best possible phase noise performance and easy mode selection in the multi-mode sapphire resonator. The sapphire resonators are cooled by liquid nitrogen to an operating temperature of 80 K, a temperature achievable in spacecraft using radiative cooling, for an operational Q of 10(exp 7). Except for the sapphire resonator, all components operate at room temperature for flexibility and ease of testing. The output frequency of 8.1 GHz is generated from a 100 MHz voltage controlled oscillator (VCO) local oscillator, which frequency will also be used for output and test. Sapphire resonators have been ordered with frequencies slightly below the desired operational frequency, and will be cut to final size after measurement of their resonant frequency at 80 K. Being thermally uncompensated, the thermal coefficient of frequency is substantial at 80 K. For this reason a thermal design was chosen that uses radio frequency (RF) heating in the resonator to stabilize its frequency to that of the local oscillator (LO) for times longer than a few seconds and thermal inertia for shorter times. This design allows the full potential of the phase noise reduction of the sapphire resonator STALO design to be achieved.

W91-70164
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **157-01-70**
LIGHT SCIENCE EXPERIMENTS AND MISSION ENHANCEMENTS WITH LASER COMMUNICATION LINKS TO PLANETARY SPACECRAFT
B. L. Schumaker 818-354-4169

The objective of this RTOP is to define science experiments that could be accomplished with first-generation laser communication links to planetary spacecraft, including definition of requirements on spacecraft laser packages and uplink capabilities, and required or desirable technology development. This will be a 0.7-workyear study, culminating in a written report. Science such as gravity-mapping, scattering through planetary rings and atmospheres, atmosphere, cloud, and dust studies, and other areas addressed conventionally by radio signal analysis will be considered in the context of optical signals. Such experiments will be examined critically for their information content and degree of complementarity to or improvement over radio-science experiments. The study will also explore science experiments with laser light whose analogs at radio frequencies are difficult or impossible, such as some solar studies and tests of relativity. Emphasis will be placed on science that could be accomplished with intensity data only (as opposed to both amplitude and phase information), since first-generation laser communication links will be incoherent rather than coherent.

W91-70165
Goddard Space Flight Center, Greenbelt, MD. **157-03-50**
X-RAY, GAMMA-RAY AND NEUTRON/GAMMA-RAY INSTRUMENT AND FACILITY PROGRAM
J. I. Trombka 301-286-5941

The objective of this investigation is to develop remote-sensing and in-situ measurement systems for geochemical and geophysical exploration of the planets, asteroids and comets. These studies will be consistent with planetary programs recommended by the Solar System Exploration Committee (SSEC). The remote-sensing x ray spectrometer study will consider proportional counters, solid-state detectors, and imaging systems. Elemental composition for elements with atomic numbers greater than Z-6 (carbon) using solar x ray fluorescent spectral measurements are being considered. Both theoretical and experimental studies will be used in the investigative program. Both gamma ray and x ray detector systems are significantly affected by the space radiation environment. Both induced backgrounds and radiation damage in gamma ray detectors (i.e., NaI(Tl), CsI(Na), Ge(Li) and He(High Purity) have been studied and methods for predicting the magnitude of these effects of the space radiation environment have been developed. Balloon flights of remote sensing gamma ray and x ray spectrometer systems will be conducted in order to ascertain their sensitivities and the magnitude of the space environment induced activity.

W91-70166
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **157-03-70**
LUNAR OBSERVER IMAGING
J. L. Anderson 818-393-7818

A continuation of imaging instrument advanced development is proposed. Due to FY-91 new start status for CRAF/Cassini, it is proposed that this effort be directed toward items requiring early resolution for planning an imaging subsystem for the Lunar Observer program. Among those items are preliminary testing of candidate commercial lenses, preliminary design of charge coupled device (CCD) focal planes for each camera, preliminary analysis of high-speed data handling and interaction of emerging mission operations with imaging subsystem requirements. Candidate commercial lenses will be purchased and tested in the commercial mounting to determine the modulation transfer function at several places in the field of view and at several spatial frequencies. This will provide key information on the suitability of these lenses for meeting Lunar Observer requirements. Each of the three required CCD focal planes will be designed and the production specifications prepared. This will allow a timely start of procurement activities for these long-lead items. The high resolution pushbroom camera requires such a high readout rate that parallel readout, square rooting and data compression will be required. Analysis of the required signal chain electronics requires early preliminary analysis to assure appropriate parts are included in Project procurement.

W91-70167 **157-03-70**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY ADVANCED LANGMUIR PROBE TECHNIQUES
W. R. Hoegy 301-286-3837

The goal of this research is to improve the Langmuir probe technique for future use in the outer regions of the solar system and to design a modified probe to measure the solar photoemission current while the satellite is within a planetary ionosphere. 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 extreme ultraviolet (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. A new proposed use for the probe is the measurement of the photoemission current in the ionospheres of the inner solar system (Venus, Earth, and Mars). A new grid system will be designed to exclude current collection due to ambient ions and electrons, allowing the probe to measure photoemission current which is proportional to the integrated solar flux. The resulting solar flux monitor will permit measurements of the solar flux simultaneously with the in situ planetary atmospheric and ionospheric measurements. 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.

W91-70168 **157-04-80**
Ames Research Center, Moffett Field, CA.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM - TITAN ATMOSPHERIC ANALYSIS
G. C. Carle 415-604-5765
(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. The approach of the RTOP is to develop a highly efficient aerosol collector for use in the atmosphere of Titan and other planetary bodies of interest. Aerosols gathered from this collector will be analyzed with a gas chromatograph-ion mobility spectrometer so their chemical composition may be determined.

W91-70169 **157-05-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY
J. Brasunas 301-286-3488
(196-41-50; 196-41-54)

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. A new task is to develop higher sensitivity far-infrared detectors compatible with passive radiative coolers on long-term missions (greater than 5 years). Specifically, this task will develop high-temperature superconductor (HTS) bolometers for outer planet missions such as the 1996 Cassini mission to Saturn and Titan, and for long-term Earth-orbiting missions such as Earth Observing System (Eos) and the Space Station.

Oceanic Processes

W91-70170 **161-30-02**
Goddard Space Flight Center, Greenbelt, MD.
OCEANIC PHYSICAL-BIOLOGICAL PROCESSES
Charles R. McClain 301-286-5377

This RTOP contains tasks that (1) apply ocean color data and related environmental data sets to investigations of oceanic processes; (2) develop software and hardware systems for the analyses of those data sets; and (3) develop and maintain the existing Oceans Computer Facility. Because data analysis and interpretation are closely connected to analysis software and hardware systems, the tasks under this RTOP consist of both science applications and system development/maintenance. Experience has shown that the most efficient and productive computing scenario is one that allows the scientists to participate and even oversee the computing environment in which they work. In this RTOP, the science tasks focus on the couplings between biological and physical oceanic processes. These tasks are (1) Investigations of Oceanic Physical-Biological Couplings; (2) Equatorial Pacific Productivity; and (3) Coastal Zone Color Scanner Studies in East China Sea. The system development and maintenance tasks are (1) Support for PC-SEAPAK Development and Distribution and VAX-SEAPAK Maintenance; and (2) Goddard Space Flight Center Group Computing.

Space Physics SR&T

W91-70171 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
HELIOSPHERIC PHYSICS
T. A. Parnell 205-544-7690

An observational program to study cosmic ray composition, spectra, and interactions in the region 10 to the 12th power to 10 to the 14th power 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 the 14th power to 10 to the 16th power 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 the Marshall Space Flight Center: (1) apply three-dimensional hadronic-electromagnetic cascade simulation of x ray film spots and scanning microdensitometry to measure primary energy and produce 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 to the 14th power 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.

W91-70172 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
HELIOSPHERIC PHYSICS
T. A. Parnell 205-544-7690

After completing the development of the Bristol University Gas Spectrometer Four (BUGS-4), a balloon-borne measurement of the cosmic ray composition (oxygen through iron) and spectra between 20 and 1000 GeV/nucleon will be performed. The instrument uses two Cerenkov counters in spherical shell (radius 1.4 meters) diffusion boxes to measure the primary charge. A spherical gas-filled detector in the center measures impact parameter (trajectory information and energy to approximately 1000 GeV/nucleon). This is measuring the time of arrival and pulse height of a drift pulse. The instrument is mechanically complete, including the Cerenkov radiators and photomultiplier tube assemblies. The instrument will be shipped to Huntsville, AL and refurbished, including replacing components if necessary. Flight electronics and ground support equipment will be designed and developed. The instrument will be calibrated and a balloon-borne observation will be made, followed by analysis of the data. This is a joint project between the Marshall Space Flight Center, the University of Alabama in Huntsville, and Bristol University, England.

W91-70173 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
HELIOSPHERIC PHYSICS
S. T. Suess 205-544-7611

We are developing analytical, numerical, and empirical models while studying magnetohydrodynamic (MHD) waves, the heliospheric termination shock, and the morphology and phenomenology of coronal and interplanetary magnetic fields. The 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, researchers 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 dependencies and variations with solar cycle, and considering possible dynamic time-dependent effects. With regard to coronal and interplanetary magnetic fields, researchers are conducting several studies including: (1) 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; (2) empirical studies of the location of coronal mass ejections with respect to hydrogen-alpha spectral line maps of the Sun; and (3) further consideration of ripples on the heliospheric current sheet (now as a kinematic effect). Data resources include Solar Maximum Mission (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.

W91-70174 **170-10-10**
Goddard Space Flight Center, Greenbelt, MD.
COSMIC AND HELIOSPHERIC PHYSICS
J. F. Ormes 301-286-5705

This RTOP is to support efforts within the Space Sciences Directorate at the Goddard Space Flight Center aimed at understanding the acceleration, interactions and transport of energetic particles in astrophysical plasmas. The approach is to study energetic particles of galactic and solar origin in order to understand their propagation in galactic and solar system magnetic fields, and to study the properties of the space plasmas in which their acceleration takes place. The particles observed are the nuclear and electronic species: their energy spectra, their charge states and isotopic composition, and their distribution in space. Planning of new missions is an important component of this research as analysis leads to increased understanding but more sophisticated questions. 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, International Sun-Earth Explorers (ISEE), Interplanetary Monitoring Platform (IMP), and Helios and comparisons with data from other observatories, both space and ground based. A strong emphasis is placed on creating the theoretical framework for interpreting the results. This RTOP supports graduate student thesis research, research associates, and occasionally a senior faculty member on leave from an academic institution.

W91-70175 **170-10-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSMIC AND HELIOSPHERIC PHYSICS
R. Goldstein 818-354-0241

This RTOP consists of seven subtasks: (1) Magnetospheric and Interplanetary Data Analysis: Analysis and interpretation of Pioneer, International Sun-Earth Explorers (ISEE) vector helium magnetometer data and ISEE plasma wave data; (2) Radio Analysis of Interplanetary Scintillations (Probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of spacecraft radio signals); (3) Solar Wind Data Analysis (Investigations of heliospheric physics, including the acceleration of the solar wind and stream-stream interactions, using solar wind data acquired by past missions); (4) Magnetohydrodynamic (MHD) Processes in the Solar Wind (Theoretical analysis of wave and shock processes in the solar wind); (5) Propagation of Solar Wind to the Outer Heliosphere (2-D MHD modeling of propagation of solar wind disturbance); (6) Giotto Solar Wind Data Analysis (Investigation of heliospheric physics, using Giotto ion mass spectrometer data); and (7) Causes of North-South Bz Variations in Interplanetary Driver Gases (Examine magnetic structure in high speed streams using ISEE-3 data).

W91-70176 **170-10-10**
Ames Research Center, Moffett Field, CA.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
A. Barnes 415-604-5506

The objective of this RTOP is to improve the understanding of the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. The approach of this RTOP is 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.

W91-70177 **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 interplanetary 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 extreme ultraviolet (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, multilayer optical coatings, and 2-D hard x ray detectors.

170-38-51

W91-70178
Marshall Space Flight Center, Huntsville, AL.
DEVELOPMENT/SOLAR PHYSICS RESEARCH
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). A High Resolution Gamma Ray and Hard X Ray Spectrometer (HIREGS) has been selected for flight as part of the Max '91 Initiative. The HIREGS investigations will be managed and funded through Marshall Space Flight Center. The program will consist of a test flight to take place in CY-91 and a long-duration flight in CY-92. A definition phase has been completed and the University of California at Berkeley has been awarded a continuing grant for phase 3/4.

170-38-51

W91-70179
Marshall Space Flight Center, Huntsville, AL.
DEVELOPMENT/SOLAR PHYSICS RESEARCH
John M. Davis 205-544-7600
(188-46-01)

Controls, Astrophysics, and Structures Experiment in Space (CASES) is a joint initiative of Marshall Space Flight Center and Langley Research Center for the study of the behavior of large structures in space within the framework of the Control Structures Interaction (CSI) Program. Through the use of a 32-m extendable boom mounted to the Space Transportation System (STS), CASES will study the pointing, figure control, and the vibration suppression of a flexible structure, 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 3/4 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 one year prior to launch which is currently scheduled for May 1994. The activities of the SWG will be supported through this RTOP.

170-38-52

W91-70180
Marshall Space Flight Center, Huntsville, AL.
GROUND-BASED OBSERVATIONS OF THE SUN/SOLAR PHYSICS
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 Marshall Space Flight Center (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 principle investigators (PI's) and other relevant personnel, and coordinated observing programs associated with collaborative investigations with mission PI's.

170-38-52

W91-70181
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, thereby complementing ultraviolet (UV), extreme ultraviolet (EUV), x ray, and gamma ray observations made from NASA spacecraft, sounding rockets, and balloons; (2) To support operational planning for flight-mission experiments and to measure solar inputs for predicting space environment parameters needed for orbital flight dynamics and manned mission activities; and (3) To conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions. The National Solar Observatory's (NSO) Vacuum Telescope at Kitt Peak, Arizona is supported by the laboratory through its Southwest Solar Station. High resolution, full disk magnetograms and He I 10830A spectroheliograms are routinely obtained and substantial observing time is dedicated for special purpose programs of spacecraft support and basic research by Laboratory staff. Solar oscillations are observed during campaigns in the Antarctic with high spatial resolution instrumentation which has been modified and is being placed into regular service at the Vacuum Telescope. Collaborative instrumentation and research programs are initiated and maintained with the NSO and other colleagues.

170-38-53

W91-70182
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. Focus will be 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 sub-photospheric 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 and impacts observations of the Sun across the entire electromagnetic spectrum, from radio frequencies to gamma rays.

170-38-53

W91-70183
Marshall Space Flight Center, Huntsville, AL.
LABORATORY AND THEORETICAL SOLAR PHYSICS
R. L. Moore 205-544-7613
(170-38-53)

The general objective is to determine and understand basic empirical properties of solar magnetic fields and their effects in the solar atmosphere. The general approach is to analyze Marshall

Space Flight Center (MSFC) vector magnetograms along with complementary data from solar space missions and from ground-based observatories, and to interpret observed effects with physical models. The results will guide choices of specific observing programs for future solar space missions, including SOLAR-A, the Solar and Heliospheric Observatory, and Orbiting Solar Laboratory. Active regions will be studied to determine: (1) form and action of the magnetic field in flares and coronal mass ejections; and (2) magnetic canopies of sunspots. Quiet regions will be studied to determine: (1) fine-scale magnetic structure of the network and its implications for the heating of the transition region and corona; (2) microflares and their relation to coronal heating and spicules; and (3) Alfven-wave trapping and heating in coronal holes.

W91-70184
Marshall Space Flight Center, Huntsville, AL. **170-38-53**
LABORATORY AND THEORETICAL SOLAR PHYSICS
D. H. Hathaway 205-544-7610

The objective of this RTOP is to develop an understanding of the dynamics of the solar convection zone and the nature of the solar activity cycle. The approach is to analyze data to determine how the Sun behaves and then use numerical models to emulate this behavior on a computer. Data from instruments like the Solar Oscillations Imager (SOI) on the Solar and Heliospheric Observatory spacecraft will be analyzed to determine the characteristics of the flows within the solar convection zone. Data from historical records of sunspots will be examined to find detailed information about the behavior of the sunspot cycle. Computer programs will be developed to model the dynamics of the solar convection zone with embedded magnetic fields.

W91-70185
Marshall Space Flight Center, Huntsville, AL. **170-38-53**
LABORATORY AND THEORETICAL SOLAR PHYSICS
J. F. Dowdy, Jr. 205-544-7604

The objective of this research is to determine the limits of steady-state models for the quiet solar atmosphere. The techniques being developed to meet this objective will also provide important support for NASA solar missions. The program can be broken into three parts: (1) development of a realistic model for the magnetic field which will be based on observed magnetic field distributions and of computer algorithms to calculate and display the model; (2) development of a three-dimensional temperature structure by including the previously computed magnetic field into a steady-state energy balance model; and (3) calculation of the extreme ultraviolet (EUV) emission structure expected to be observed from the model. The emission structure which is calculated from the model can then be compared to the observed EUV mission structure. These models and techniques will be important for interpretation of space flight data from past NASA missions and future missions.

W91-70186
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **170-38-53**
SOLAR PLASMA MODELING AND MEASUREMENTS OF COLLISION PARAMETERS
R. Goldstein 818-354-0241

This RTOP consists of two subtasks: (1) Coronal Magnetic Reconnection Models; and (2) Solar Plasma Diagnostics. The purpose of the coronal magnetic reconnection models 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. The 1-D, 2-D and 3-D 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 process plays a role in more violent coronal events such as flares. The purpose of the solar plasma diagnostics 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 JPL, using merged electron and ion beams, trochoidal energy analysis, and spatial detection of electrons using a microchannel plate.

Solar Terrestrial and Astrophysics SR&T

W91-70187
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-41-22**
RELATIVITY, COSMOLOGY, AND GRAVITATIONAL RADIATION
R. A. Preston 818-354-6895

The objectives of this RTOP are theoretical and observational investigations of cosmic gravitational waves to define sources, strengths, and detection methods, and planetary radar and lunar laser ranging observations to study the relativistic dynamics of the solar system. In FY-91, the relativity program will: (1) continue a study of the continuous gravitational wave background using millisecond pulsar data; (2) study interferometer technology for gravity wave detection in space; (3) develop signal processing methods for very low frequency gravitational wave searches; (4) continue research on gravitational wave astronomy and cosmology including a new geometric formulation of moving frame analysis to be applied to the theory of rigidly rotating self-gravitating fluid spheroids; and (5) support observational tests of relativistic gravity theory, including geodetic precession and possible time variation in the gravitational constant, using planetary ranging and lunar laser ranging.

W91-70188
Goddard Space Flight Center, Greenbelt, MD. **188-41-23**
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
George Sonneborn 301-286-3665

Space based instrument systems for astronomy offer scientists many important advantages. 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 infrared), 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 systems design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. Investigations are presently being conducted in 2 technical areas that will have substantive cost/performance payoffs. In optical materials research, major emphasis was placed on ultraviolet mirror coating developments to improve system throughput. In the area of diffraction grating technology, studies of advanced design, fabrication, and testing methods are being conducted.

W91-70189
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-41-23**
OPTICAL INTERFEROMETRY FROM SPACE
M. Shao 818-354-7834

Optical interferometry is the only route to very high angular resolution optical astronomy. Resolutions equivalent to filled apertures 100's of meters in diameter are possible in space, and baselines to 10 km are possible on the Moon. Proposed space interferometers include Optical Stellar Interferometer (OSI) and Precision Optical Interferometry in Space (POINTS), while an optical interferometer has been proposed as one of the premier science instruments for a lunar base. The Mark 3 OSI is a long baseline optical interferometer located on Mt. Wilson. This operational instrument incorporates much of the technology required for space and lunar interferometers: precision optical delay lines, coherent fringe tracking, laser metrology geometry monitoring, and fully automated operation, and thus serves as a valuable technology testbed. Engineering experience with an operational instrument provides crucial technological input to the design of future instruments. In addition, the scientific utility of such an instrument is in a large degree dependent upon observational aspects: calibration, observing sequence, baseline selection, etc. Observing experience with its predecessors strongly influenced the Mark 3 design. Similarly, observing experience with the Mark 3 will strongly influence the design of space and lunar interferometers, ensuring the development of the most scientifically productive instruments possible. Thus, an observing program is proposed for the Mark 3 interferometer, including wide angle astrometry, stellar diameters, and binary star measurements. Previous observations have demonstrated astrometric precisions 5 to 10 times greater than conventional techniques, and imaging resolutions well beyond the capability of speckle techniques. The emphasis is on understanding the instrument, in order to improve upon it in future space instruments, by looking at such issues as calibration to the 1 percent level, and also on performing unique high resolution science, which, at present, can only be accomplished with the Mark 3.

W91-70190
Goddard Space Flight Center, Greenbelt, MD. **188-41-24**
ULTRAVIOLET DETECTOR DEVELOPMENT
Bruce E. Woodgate 301-286-5401

The objective of this RTOP is the development of photon counting detectors and charge coupled devices (CCDs) 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 ultraviolet enhancement of CCDs will be explored. Work will be directed to improving internal efficiencies and the readout method and to reducing the effective pixel size of the Multi-Anode Microchannel Array (MAMA) detector. Hybrid circuitry will be developed for use in a miniaturized 1024 x 1024 square pixel MAMA detector.

W91-70191
Goddard Space Flight Center, Greenbelt, MD. **188-41-51**
UV ASTRONOMY AND DATA SYSTEMS
A. V. Sweigart 301-286-6274

The objectives of this RTOP are: (1) to perform theoretical and observational astronomical research of particular interest for space observations; (2) 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; (3) to support an optical telescope observatory for testing research ideas for space projects; and (4) to develop new instrumentation for observing astronomical objects. The approaches of this RTOP are 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, utilizing 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; and (5) develop tools and techniques for using astronomical data bases, and incorporate new astronomical data sets and maintain currency of the databases via journal searches.

W91-70192
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-41-57**
LABORATORY ASTROPHYSICS
J. M. Ajello 818-354-2457

Laboratory astrophysics studies of electron impact cross sections and lifetimes of cosmically abundant atoms, molecules and their ions are conducted at JPL. The resulting data are available for analysis of Hubble Space Telescope and Lyman Explorer observations of ultraviolet (UV) spectra. The laboratory data will be generated by performing experiments using: (1) electron impact excitation to measure UV fluorescence spectra at high spectral resolution; (2) electron energy loss, merged beams to measure absolute collisional excitation line strengths in singly and multiply charged ions; (3) beam-beam electron scattering techniques to measure excitation cross sections for atoms and molecules, and total cross sections for singly-charged ions; and (4) lifetimes at high time resolution. The principal application of these atomic and molecular parameters are to model observations of diffuse molecular clouds, the interstellar medium and stellar atmospheres.

W91-70193
Goddard Space Flight Center, Greenbelt, MD. **188-44-01**
RESEARCH COMPUTING FACILITY AND CATALOGING FOR INFRARED OBSERVATIONS
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.

W91-70194
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-44-21**
OBSERVATIONAL RADIO/INFRARED ASTRONOMY
R. A. Preston 818-354-6895

JPL has active research groups in cm-wavelength very long baseline interferometry (VLBI) and in spectroscopy from cm to sub-mm wavelengths. The primary emphasis of the VLBI group is active extragalactic objects (quasars, BL Lac objects, Seyfert galaxies) and galactic radio stars (RS CVn and Mira variables). The primary interest of the radio spectroscopy group is the interstellar medium of this galaxy, including molecular clouds and outflows from late-type stars. This RTOP combines the following tasks: (1) High Resolution Studies of Active Galactic Nuclei; (2) Nuclear Enrichment of the Interstellar Medium; (3) Interstellar Microwave Spectroscopy/Observations; and (4) Tidbinbilla Interferometer.

W91-70195
Goddard Space Flight Center, Greenbelt, MD. **188-44-23**
INFRARED, SUBMILLIMETER, AND RADIO ASTRONOMY
N. W. Boggess 301-286-6989
(188-44-23)

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 take maximal advantage of low background conditions at those altitudes. A balloon-borne 1.5 m telescope is used to measure the small scale anisotropy of the cosmic background radiation; an infrared camera is used to image efficiently galactic and extragalactic sources. Infrared and submillimeter spectrometers are used to detect and resolve intensity profiles for molecular and atomic lines. Correlative studies, including radio observations, are made to enable maximum insight into the physics of the medium. Tools and techniques which will facilitate and improve data reduction, analysis, and understanding of astrophysical data are being developed.

W91-70196 **188-44-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMILLIMETER WAVELENGTH OBSERVATIONAL ASTROPHYSICS
S. Gulkis 818-354-5708
(188-44-21)
The objectives of this activity are to study the interstellar medium using very high spectral resolution submillimeter wave astronomical observations of molecular and atomic transitions. The observations will probe the physical conditions in star forming regions and circumstellar envelopes of late-type stars. Submillimeter wave spectral lines provide diagnostics of the very dense, warm interstellar gas as it interacts with stellar objects: protostars, T-tauri stars, and late-type stars. Submillimeter spectral line observations offer the clearest means to study the physics of these objects. In spite of its great importance, the submillimeter spectral range remains relatively unexplored. The primary reasons for this include the fact that the Earth's atmosphere is largely opaque in the submillimeter spectral range, and the fact that the technologies needed for receiving submillimeter waves are still in their infancy. This activity places strong emphasis on the development and use of state-of-the art submillimeter wavelength heterodyne receivers. In particular, cooled 'superconductor insulator superconductor' (SIS) receivers will be developed under this task for specific airborne, balloon, and mountaintop observatories. This activity lends strong support to future spaceborne, astronomical submillimeter missions based on high spectral resolution (heterodyne) spectroscopy.

W91-70197 **188-44-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED IMAGING PALOMAR
C. Beichman 609-734-8073
The Near Infrared Camera at Palomar was designed to image a variety of galactic and extra-galactic sources in the 1 to 2.5 micron spectral region using a large field of view at the prime focus of the Hale 5m telescope. In FY-89, a camera, incorporating a 128 x 128 array of HgCdTe detectors on a Reticon readout, was put into operation. The quantum efficiency of the device is approx. 40 percent. The readout noise was approx. 1000 electrons. In FY-90, the camera was upgraded with a 256 x 256 array with a 600 electron readout noise. The 256 x 256 array gives a spatial resolution of 0.5 sec and a 128 sec field of view. Toward the end of FY-90 the detector technology will be changed completely and a 128 x 128 Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) array with 20 to 50 electrons of readout noise will be incorporated. Three papers and a number of conference contributions are in press using results from the camera. Major results include the first detection of the 1.64 micron line of ionized iron in protostellar sources. The camera was used to study a number of Herbig-Haro objects in lines of Fe II and shocked molecular H2. High resolution maps of the ionized and shocked molecular material are unraveling the complex dynamics of the region where an energetic wind interacts with ambient cloud material. Fe II will provide a useful probe of regions of low ionization in highly obscured regions. Hester et al. observed supernova remnants in lines of Fe II and the continuum. Comparisons of the infrared lines with optical lines led to the discovery of abundance variations related to abundances in the supernova ejecta. Terebey et al. imaged more than 20 protostellar regions to compare their infrared appearance with CO maps made with the Owens Valley interferometer. Many sources show strong correlations between the 2 micron images and the interferometer maps. The source TMR-1 shows a particularly interesting morphology with a pronounced disk seen in absorption against an outflow cavity seen illuminated by scattered light. The outflow cavity shows up as a gap in the (13)CO emission in the interferometer maps. Another project underway with the camera is a morphological study of infrared luminous galaxies found by Infrared Astronomical Satellite (IRAS).

W91-70198 **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 415-604-6426
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.

W91-70199 **188-44-53**
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF GALAXIES, THE INTERSTELLAR MEDIUM, MOLECULAR CLOUDS, STAR FORMATION
B. F. Smith 415-604-5515
The objective of this research is to better understand: (1) the formation and evolution of galaxies and clusters of galaxies; (2) basic processes which determine the state and infrared radiative properties of the interstellar medium in galaxies; (3) molecular clouds and star formation; and (4) the structure and evolution of the atmospheres of evolved stars. 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 multi-dimensional hydrodynamic and magneto-hydrodynamic 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.

W91-70200 **188-44-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL INFRARED/RADIO RESEARCH
D. L. Meier 818-354-5062
The purpose of this research is to support the NASA space-based and ground-based observations in the radio and millimeter regions of the spectrum with theoretical work to improve the understanding of atomic and molecular processes in interstellar clouds and to improve the understanding of hydrodynamical and magneto-hydrodynamical processes in radio sources. In FY-91 these programs will use existing techniques to model OH and CO in the outer regions of dark galactic clouds, NH3 in quiescent cloud cores, and extragalactic jets with realistic helical magnetic field geometries for comparison with existing radio source images. New techniques will be developed to model very high optical depths of interstellar submillimeter hydride emission lines, and their kinematics' and geometry, and to model the production of extragalactic jets in magnetic accretion disks around black holes.

W91-70201 **188-44-55**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROPHYSICS SUPPORT
P. N. Swanson 818-354-3273
This RTOP provides general support to the astrophysics program office to fund outstanding visiting scientists for

collaborative efforts with NASA, special meeting support, and other ad hoc assignments for which no specific RTOP applies.

188-44-57

W91-70202
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED/RADIO LABORATORY ASTROPHYSICS
H. M. Pickett 818-354-6861

The objectives of this RTOP are to: (1) improve the understanding of atomic and molecular processes in the interstellar clouds and stellar atmospheres through laboratory experimental work; and (2) develop and extend the JPL submillimeter and microwave line catalog.

188-44-57

W91-70203
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 analyses and studies to model appropriate systems are undertaken. The objectives of the specific tasks supported under this RTOP are: (1) to obtain high resolution spectra (one part in 10(exp 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 Space Infrared Telescope Facility (SIRTF) and Stratospheric Observatory for Infrared Astronomy (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 using 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 temperature cryostat and FTS while (5) requires both of these systems, plus a 1 MeV proton accelerator.

188-44-57

W91-70204
Ames Research Center, Moffett Field, CA.
PROPERTIES OF INTERSTELLAR PAHS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to understand why free molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects. They 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 to further understand the roles of PAHs in astrophysics. Experiments are underway in which PAHs are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found.

188-46-01

W91-70205
Goddard Space Flight Center, Greenbelt, MD.
HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES
J. F. Ormes 301-286-5705

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of x ray and gamma ray astronomies, energetic particles and cosmological studies. Multisatellite data sets, such as those of Ariel 5, Orbiting Solar Observatory (OSO) 8, High Energy Astrophysical Observatory (HEAO) 1 and 2 provide a basis of information which for many x ray sources remains complementary to the results of recent missions such as EXOSAT and Ginga, and upcoming missions such as Roentgen Satellite (ROSAT) and Broad-Band X Ray Telescope (BBXRT). 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 repository 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 an occasional senior faculty member on leave from an academic institution.

188-46-01

W91-70206
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)
F. C. Witteborn 415-604-5520

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. The research will be expanded by increasing the number of parameters needed to describe the magnetic fields and their geometry and including the details of the radiative transfer at the surface of the expanding wind.

188-46-57

W91-70207
Goddard Space Flight Center, Greenbelt, MD.
GAMMA RAY ASTRONOMY
Carl E. Fichtel 301-286-6281

The technical objective of this RTOP 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 have been pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma ray observations. In the high energy region improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons, and sensitivity, including the study of techniques to build much larger systems. Improved approaches to the energy measurement and coincidence system also are being pursued. 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.

W91-70208
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-46-57**
GAMMA-RAY ASTRONOMY AND TECHNOLOGY DEVELOPMENT
W. A. Mahoney 818-354-6606

Future gamma ray spectroscopy experiments will require greatly improved imaging capabilities in order to avoid source confusion problems, to locate point sources well enough to allow identification with known objects, and to map the steep gradients expected toward the galactic center for diffuse sources. These research and analysis tasks involve the development of advanced segmented germanium detectors together with the appropriate coded aperture or Fourier transform masks which will provide the basis for an instrument which will combine such imaging capabilities with superb energy resolution. During the multi-year program, a series of segmented germanium detectors will be fabricated with increasingly improved imaging capabilities. During FY-90, the background suppression capabilities of a previously fabricated externally segmented germanium detector were measured and compared with the performance predicted by Monte Carlo modeling. The fabrication of a second segmented detector is nearing completion. This second detector will be in a mounting capable of withstanding balloon flight operations and either it, or a third and larger segmented detector, will be test flown on a balloon from the Southern Hemisphere during FY-91. During the latter part of FY-90 and throughout FY-91, appropriate coded aperture and Fourier transformation masks will be built and tested with the segmented detectors. Of particular interest will be the imaging performance of the system at high energies (MeV) where multiple Compton scatterings are typical. A data acquisition system based on computer automated measurement and control (CAMAC) modules is presently being designed and will be operational by the end of the year. Once the data system is functional, data analysis algorithms will be developed and optimized for image deconvolution near an MeV. Segmented germanium detectors will almost certainly be used as the prime sensors in the next space based gamma ray experiment beyond the Gamma Ray Observatory. Most of the technology developed under this task will be directly applicable to such a mission.

W91-70209
Goddard Space Flight Center, Greenbelt, MD. **188-46-58**
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 of 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.

W91-70210
Goddard Space Flight Center, Greenbelt, MD. **188-46-59**
X-RAY ASTRONOMY
E. A. Boldt 301-286-5853

Celestial x ray sources have introduced 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 broadband width has been the approach in discovering and exploring these phenomena. The power of this approach has been well demonstrated. Extending it with improved spectral resolution and broadband imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise detectors of optimum energy resolution, large area x ray concentrators, imaging devices, and monitoring instrumentation.

W91-70211
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **188-46-59**
X-RAY ASTRONOMY CCD
S. A. Collins 818-354-7393

The objective of this task is to develop a charge coupled device (CCD) which is suitable for use as an astronomical detector of soft x rays and to support the use of this detector in a rocket-borne instrument to acquire energy resolved x ray images of astronomical sources. This task will be accomplished by designing and fabricating CCDs which combine proven features which provide high sensitivity at photon energies of 0.3 to 2.0 KeV with very low noise (approx. 0.5 electrons, rms) signal readout.

W91-70212
Marshall Space Flight Center, Huntsville, AL. **188-46-59**
X-RAY ASTRONOMY
M. C. Weisskopf 205-544-7740

This RTOP program conducts 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 relate variations in intensity to any spectral variability; (4) to study the infrared properties of x ray emitting clusters of galaxies; (5) to interpret the results in terms of existing theoretical models or to establish new theoretical models if required and feasible; and (6) to utilize these results in guiding the design of instrumentation. Another main objective of this 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. They will have applications in imaging, timing, and spectroscopy. In addition, new techniques for focusing x rays, particularly at energies above those accessible to current (reflecting) x ray telescopes, will be explored, as well as new methods for detecting x ray polarization.

W91-70213
Ames Research Center, Moffett Field, CA. **188-48-52**
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-604-4164

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. Our comprehensive investigation includes studies of patterns of star-forming regions on galaxy wide scales; dynamics, structure, energetics, and chemistry of the interstellar medium; details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; possible differences in the formation of high and low mass stars; formation and evolution of protostars and nebular disks; mechanisms of planetary system formation and disk dispersal; the origin of bipolar flows and their effect on the surrounding gas and dust; the effect of the radiation from young stars on circumstellar material; and the origin of water masers and Herbig-Haro objects associated with star-forming regions.

W91-70214 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TECHNOLOGY DEVELOPMENT IN RELATIVITY AND OPTICAL INTERFEROMETRY
R. W. Hellings 818-354-3192

The purpose of this research is to investigate technology issues for missions to test the foundations of relativistic gravitation and to detect gravitational waves, and to qualitatively assess the scientific capabilities of several optical interferometer designs, identifying the technological developments needed to achieve the goal of deploying a high resolution imaging or astrometric instrument in space in the near future.

W91-70215 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REQUIREMENTS AND TECHNOLOGY DEFINITION FOR SPACE-BASED ASTROPHYSICS
M. J. Mahoney 818-354-5584

The objectives of this RTOP are to understand the scientific opportunities provided by, and the technology developments needed for, future space-based astrophysics missions. Telescope and instrument definition studies will be made and promising technology opportunities will be explored for proposed submillimeter missions. In addition, the technology requirements of all future astrophysics missions will be assessed. Two potential submillimeter space-based mission concepts will be studied: the Submillimeter Moderate Mission (SMMM) and the Large Deployable Reflector (LDR), with the emphasis on the former. System modelling will help develop requirements for a focussed mission telescope being built as part of the Civil Space Technology Initiative (CSTI)/precision segmented Reflector (PSR) program; characterization studies of receiver front- and back-ends will identify and explore promising technologies; technology needs will be identified for all future astrophysics missions. The modelling activity will continue to support the CSTI/PSR technology program by providing the analysis necessary to define telescope performance requirements as they relate to the science needs. The receiver characterization studies will explore the use of SIS devices as fundamental mixers at frequencies greater than 1 THz and as harmonic mixers at lower frequencies, and they will also examine promising new technologies for use as low power, high bandwidth spectrometers. Having developed an implementation plan and strategy, a focussed technology plan for the key technology areas of sensors, optics, and information systems will be developed for each discipline area.

W91-70216 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE INFRARED TELESCOPE FACILITY (SIRTF)
R. J. Spehalski 818-354-3506

The objectives of this RTOP are: (1) a telescope capable of diffraction limited observations at 3 microns; (2) five year lifetime in a high Earth orbit with observing efficiency of 80 percent or greater; (3) sensitivity limited by naturally occurring celestial backgrounds from 2.5 to 200 microns; (4) optimized performance for wavelengths from 200 to 700 microns; and (5) support a full observatory program with the majority of observing time being allocated to guest observers. The three approaches of this RTOP will be to: initiate and complete a transition of this activity from Ames Research Center; initiate the Definition Phase of the Space Infrared Telescope Facility (SIRTF) Project at JPL including implementation of the necessary in-house and contractor efforts for the flight system, spacecraft, telescope, and science instruments; and prepare for NASA Non-Advocate Review in June, 1991 and obtain a new Project start in FY-93.

W91-70217 **188-78-44**
Ames Research Center, Moffett Field, CA.
STUDY OF LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY
D. J. Hollenbach 415-604-4164

The objective of this RTOP is to refine the scientific rationale and science requirements and to provide input in 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 in space (possibly at the Space Station), and placed in an Earth orbit to perform as an observatory for at least 10 years. It is currently in the early planning state and may be operational roughly in the year 2005. The approach of this RTOP is to undertake critical analysis of various problems relevant to the eventual deployment of LDR which emerge from the discussions of the Submillimeter 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. Currently, the work focuses on thermal background subtraction by LDR using techniques such as nodding, chopping and flat fielding. The primary objective is to determine which optical design is best suited for sensitive infrared 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 and LDR precursors is numerically solved on a CRAY 2 computer. In addition, the use of array detectors to be used on infrared and submillimeter cameras will be studied, with application to precursors of LDR like Submillimeter/Infrared Line Survey (SMILS) and Submillimeter Moderate Mission (SMMM) as well as to LDR itself.

W91-70218 **188-78-60**
Ames Research Center, Moffett Field, CA.
STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)
G. W. Thorley 415-604-5917

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 infrared (IR) astronomy program into the 1990s 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 system, 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

W91-70219 **196-41-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PLANETARY ASTRONOMY PROGRAM
J. F. Appleby 818-354-3943

These interrelated research tasks address telescopic observations of all planetary bodies, atmospheres, and plasmas, including those of planets, satellites, the Moon, asteroids, comets, rings, and circumstellar disks. This research involves groundbased and aircraft telescope observations using optical, microwave, and radar techniques covering a wide range of wavelengths from the ultraviolet to centimeter radio waves. Data are obtained as narrow and broadband spectra, photometry and images in emission, absorption, and/or reflection modes. Emphasis is on obtaining characteristic information on the composition, structure, distribution and temporal behavior of planetary objects and their various components. The basic objective of this research is to obtain observational data and to couple these data with laboratory experiments and theoretical considerations in order to determine the present characteristics and evolution of planetary objects. A major objective is to establish a database for interpretive analysis of observational results obtained by unmanned spacecraft missions to planetary objects throughout the solar system, and to define new missions and new observations to further our knowledge of the solar system, of circumstellar material, and of extrasolar planets. This RTOP also supports: (1) certain science support activities at JPL's Table Mountain Observatory Facility and JPL's Goldstone Radar Observatory; (2) visiting distinguished scientists visits to JPL; (3) certain informational and educational activities; and (4) the development and application of planetary data visualization techniques.

W91-70220 **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 objective of this program is to obtain infrared spectra of planets with a combination of the highest possible sensitivity and the best resolution. A cryogenic postdisperser, developed at Goddard Space Flight Center, has been used with the Fourier Transform Spectrometers (FTS) 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/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.

W91-70221 **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, the 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 interplanetary magnetic field (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 more than 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 has 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, pressure balance conditions across the tail, etc. The sudden growth of a plasma tail in comet IRAS-Araki-Alcock may 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; a catalog of DE data consisting of 72 DEs in 29 comets between the years 1892 to 1976 has been used to probe the 3-D structure of sector boundaries to high solar latitudes. The DE results on sector structure are unique and represent the only actual probes of the IMF sector structure at high latitudes. Recently, studies of computed (potential) coronal magnetic fields have given support to the DE comet results. Nearly 300 photographic plates were obtained of Halley's Comet on 94 nights between July 20, 1985 and July 12, 1986. These images contain rich structural detail in the plasma tail: DEs, helical waves, and prominent turning tail rays are seen on many of the images. Over 100 photographic plates of comet Bradfield (1987s) were obtained during the period August 1987 through December 1987 including a spectacular disturbance of the ion tail that lasted for at least 5 nights centered on October 20, 1987. A charge coupled device (CCD) system with both narrow band International Halley Watch (IHW) comet filters and broad band BVRI filters attached to the 16 inch f/35 telescope has been added to the compliment of instrumentation available at JOCR. A second CCD can be placed behind a 300 mm lens and comet filters to provide additional wide-field imaging capability of bright comets. Calibration of the CCD/filter systems and automation of the 16 inch telescope for tracking of solar system objects has been completed.

W91-70222 **196-41-54**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED INFRARED ASTRONOMY
Michael J. Mumma 301-286-6994
(154-50-80; 157-50-50)

The objectives of this RTOP are twofold. The first objective is to study the molecular constituents of planetary atmospheres and comets through observations of their infrared (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 and spatial 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). The second objective is directed towards extending our knowledge to planetary systems that 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.

W91-70223 **196-41-67**
Ames Research Center, Moffett Field, CA.
VOLATILES IN THE SOLAR SYSTEM
D. P. Cruikshank 415-604-4244

The objective is to obtain and analyze spectroscopic data on the surfaces and atmospheres of the volatile-rich bodies (planets, satellites, asteroids, and comets) in the outer solar system. Such information is needed to interpret spacecraft observations of the planets and satellites already made and those planned for future

NASA missions to the outer solar system. An additional objective is to organize and conduct a workshop on the presence and nature of organic matter in comets in connection with NASA's plans for space missions to the comets (the Comet Rendezvous Asteroid Flyby, and Comet Nucleus Sample Return missions). The approach is to obtain astronomical observations of the planets and other bodies in the solar system with the telescopes at Mauna Kea Observatory, notably the NASA Infrared Telescope Facility, and to analyze these data using standard techniques and the body of laboratory data available for comparison. The need for additional laboratory data will be identified as appropriate. The approach related to the workshop on cometary organics consists of the identification of speakers and appropriate topics, issuance of invitations, and then the conduct of the workshop, followed by the preparation of an appropriate publication of the materials presented.

W91-70224 **196-88-00**
Langley Research Center, Hampton, VA.
DATA ANALYSIS FOR LDEF EXPERIMENTS
Louis A. Teichman 804-864-3510

The objective of this RTOP is to continue to perform post-retrieval processing, data analysis, and reporting for the following LDEF experiments: (1) Chemistry of Meteoroids; (2) Chemical and Isotopic Measurements of Meteoroids; and (3) Interplanetary Dust Experiment.

Life Sciences SR&T

W91-70225 **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 in flight 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.

W91-70226 **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 has been conducted on earth-based work environments (e.g., in Research and Development, 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; (3) to develop strategies to facilitate psychological adaptation to the space environment; (4) to integrate operational input into the identification, planning, and conduct of the research; (5) to verify baseline parameter data developed through ground-based research; and (6) to develop measurement and status monitoring procedures/hardware which are consistent with operational constraints and needs.

W91-70227 **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: (1) to quantify human performance capabilities and limitations and move toward quantification of man-machine engineering data, both on the ground and in flight; (2) to continue to pursue state-of-the-art technology and to advance that technology for the purpose of creating more effective and efficient tools for measuring or analyzing human performance; and (3) 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 approaches of this RTOP are: (1) to implement a series of continuing tasks to identify and implement practical instrumentation packages for acquiring quantitative man-machine engineering data in one-g, simulated zero-g, and actual flight conditions; (2) to continue those efforts currently defined that lead toward definitive design requirements for use as inputs to an automated crew station design system; and (3) to pursue feasibility studies of promising new crew interface items and methods.

W91-70228 **199-06-12**
Ames Research Center, Moffett Field, CA.
BEHAVIOR, PERFORMANCE AND HUMAN FACTORS
M. M. Connors 415-604-6114
(591-36-32)

The research objectives of this RTOP are to: (1) understand individual, group, and environmental/task factors that affect group performance and well-being in an aerospace context; (2) develop better methodological techniques for studying the processes mediating effects of such factors on crew outcomes; and (3) interpret and apply 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 studies have lacked generalizability because of limiting research predominately to 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.

W91-70229 **199-08-11**
Lyndon B. Johnson Space Center, Houston, TX.
GENERAL BIOMEDICAL: CENTER AND HEADQUARTERS SUPPORT
M. W. Bungo 713-483-7212

Long-duration manned space flight requires investigations that will certify the health of crew members 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 management of extensive domestic science programs, joint international ventures, and the experimental zero-g aircraft (KC-135) life science activities.

W91-70230 **199-14-11**
Lyndon B. Johnson Space Center, Houston, TX.
CARDIOPULMONARY RESEARCH
S. M. Fortney 713-483-7213

The overall objective of this program is an understanding of the cardiovascular changes (cardiovascular deconditioning) that occur with space flight and their impact on crew members. Specific aims are to: (1) define the underlying mechanisms of cardiovascular deconditioning; (2) provide appropriate countermeasures for these effects; (3) develop systems to aid in accomplishing these goals; and (4) apply the results to the selection, retention, and health maintenance of future space travelers. Ground-based studies on both human and animal subjects will in part utilize: (1) provacative techniques such as lower body negative pressure and exercise testing; (2) bedrest studies as analogs to weightlessness; (3) noninvasive and invasive cardiovascular monitoring; and (4) pharmacologic interventions, all in an effort to accomplish the goals set forth above. 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 population under a greater variety of conditions.

W91-70231 **199-14-12**
Ames Research Center, Moffett Field, CA.
CARDIOPULMONARY PHYSIOLOGY
A. R. Hargens 415-604-5746

The overall objective of this program is to develop an understanding of the cardiopulmonary and fluid-electrolyte changes occurring with spaceflight. Specific aims are to: (1) define underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short- and long-term microgravity exposure; (3) develop and test appropriate models and countermeasures to prevent or treat cardiopulmonary deconditioning; and (4) develop and implement appropriate spaceflight experiments. The approach in accomplishing this goal will involve ground-based studies on both human and animal subjects. Specific activities will include: (1) 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. This research will also provide access to flight for a broader segment of the population, and will use weightlessness to expand our understanding of cardiopulmonary/fluid-electrolyte function and autonomic nervous system control of the cardiopulmonary system.

W91-70232 **199-16-12**
Ames Research Center, Moffett Field, CA.
NEUROSCIENCE (BIOMEDICAL)
N. G. Daunton 415-604-4818

Significant changes occur in the way the central nervous system (CNS) processes sensory inputs and programs motor outputs during adaptation to the microgravity environment of space and during readaptation to Earth's gravity. These changes in CNS processing result in space motion sickness, perceptual illusions, performance deficits, and locomotion 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 reexposure 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 microgravity. The overall objective of this program is to identify CNS components and mechanisms underlying the process of adaptation/readaptation 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, behavioral and/or pharmacological countermeasures can be developed to minimize specific problems and ensure the productivity, health, and safety of astronauts in space and on return to Earth.

W91-70233 **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.

W91-70234 **199-18-12**
Ames Research Center, Moffett Field, CA.
REGULATORY PHYSIOLOGY (BIOMEDICAL)
J. Vernikos 415-604-3736
(199-14-12; 199-16-12)

The objective of this program is 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 and clotting mechanisms to health risk; and (3) the effect of the altered/adapted physiological baseline in the body's stress responding systems, on drug metabolism and on the ability of crews to respond to physical, emotional, and operational stresses and to perform. Results will improve flight and extravehicular activity (EVA) safety, contribute to EVA suit technology requirements and improve the development of safer and more effective coping skills and countermeasures to the stresses of extended spaceflight.

199-26-11

W91-70235
Lyndon B. Johnson Space Center, Houston, TX.
BONE MINERAL METABOLISM AND MUSCLE PHYSIOLOGY
M. M. Jaweed 713-483-7269

The regulation of musculoskeletal integrity and function during space flight and the causes of bone's apparent demineralization and muscle atrophy are the central questions addressed by the present research program. The mechanisms of these pathogeneses will be elucidated and defined and effective and safe physical, physiological, nutritional and pharmacological countermeasures will be developed to maintain the musculoskeletal integrity and function. The research is also focused to trace the course of bone and muscle recovery after astronauts' return to the 1-g environment, so as to afford protection against the potential hazards of osteoporosis and muscle injury. Overall, this research program is focused to maintain functional capacity of the astronauts and to develop safeguard against potential hazards both in 0-g and 1-g environment. The program entails a comprehensive evaluation of bone demineralization and muscle atrophy and their prevention at the level of organism, organ, tissue and cell. Primarily, non-invasive or semi-invasive biochemical, histochemical, physiological, nuclear magnetic resonance (NMR), tissue culture and radiological methods would be employed to define the loss of mass and function, decreased vascularity, altered regeneration and increased vulnerability to damage. The studies will be conducted with the Space Transportation System (STS) and Space Station Freedom (SSF) astronauts, bedrest or cast-immobilized subjects, experimental animals and single cells. Both field centers and the academic institutions will partake in the program.

199-26-12

W91-70236
Ames Research Center, Moffett Field, CA.
MUSCULOSKELETAL (BIOMEDICAL)
R. E. Grindeland 415-604-5756
(199-26-22)

The long-range goal of this research is to understand the process of musculoskeletal weakness and wasting in space in order to reduce or prevent its occurrence by rational countermeasures. The fundamental concern for tissues designed to support weight is a reduced function in space and injury on return to Earth's gravity. Specific goals are directed toward characterizing the time course, morphology, biochemistry, biomechanics, and physiology of the adaptation of support structures to changes in simulated weightlessness. The focus of this research is entirely on bone, muscle, and connecting ligaments and tendons. However, there is necessarily an overlap with other biomedical areas, especially, cardiovascular, endocrine, and neurologic, because of the functional interdependence of support structures with these systems. Inherent in efforts to understand the changes that occur with disuse are the development and validation of methods to monitor the process. This program uses a basic science approach, primarily, since the most effective methods for preventing and treating muscle and connective tissue atrophy, as well as bone demineralization, will be derived from a knowledge of their mechanisms. Experimental models are designed to disrupt, and/or evaluate the support function of the musculoskeletal system in whole animals or tissues. A detailed mechanistic approach, combining animal and human research, is used. Studies are coordinated with flight projects to validate the models for the 0-g environment. Preventive measures included in this research program are currently exercise, centrifugation, nutrition, and pharmacologic agents.

199-26-14

W91-70237
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, as a tool to evaluate muscle atrophy countermeasures or for pre- and post-flight monitoring of muscle. A ultrasound technique for measurement of muscle volume is also under investigation and initial tests support 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. An ultrasound scanner, spatial locator and small computer are to be assembled as a self-contained portable ultrasound muscle measurement system. 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, will be portable and has potential for inflight use.

199-30-32

W91-70238
Ames Research Center, Moffett Field, CA.
GLOBAL MONITORING AND DISEASE PREDICTION
J. S. Salute 415-604-5596
(199-30-37)

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 conducted with world health authorities has identified malaria as the primary disease to be studied. The approach is to use remote sensing and geographic information system technologies to infer environmental parameters that affect the distribution of larval (vector) habitat. Extensive field work is employed to identify the relationship between environmental parameters, such as vegetation and water, and larval habitat. Remote sensing and geographic information systems (GIS) are used to identify, characterize, and monitor many of the same environmental parameters. Remote sensing/GIS techniques are then used to predict the temporal and spatial patterns of larval habitat productivity. GIS techniques can predict disease transmission potential based on habitat productivity and human settlement/migration patterns.

199-30-62

W91-70239
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL RESEARCH IN TROPICAL ECOSYSTEMS
P. A. Matson 415-604-6884
(199-30-72; 677-21-31)

The objective of this research is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the systems. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas fluxes from soil and vegetation and estimation of their 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.

W91-70240
Ames Research Center, Moffett Field, CA. **199-30-72**
BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
D. L. Peterson 415-604-5899

The objectives of these projects 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, and to examine the effects of disturbance on these processes. 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 examine the effects of disturbance on nitrogen and water interaction, studies of how biomass combustion alters element pathways and losses will be made in collaborative experiments, emphasizing the use of remote sensing methods. In the third year, a workshop will be held to evaluate the field results.

W91-70241
Ames Research Center, Moffett Field, CA. **199-40-12**
NEUROSCIENCE (INFORMATION PROCESSING)
M. D. Ross 415-604-5757
(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.

W91-70242
Lyndon B. Johnson Space Center, Houston, TX. **199-40-21**
CELL AND DEVELOPMENT BIOLOGY
Clarence F. Sams 713-483-7160
(199-21-51)

Space flight has been demonstrated to cause a variety of alterations in biological organisms. Analysis of these adaptive processes is frequently complicated by the number of interacting systems contributing to the observed physiological changes. The use of cell biology methods frequently enables reduction of complex problems to levels that are approachable for scientific investigation. Since biological adaptation occurs as a consequence of biochemical alterations in cellular processes, detailed knowledge of basic cell function in the terrestrial and microgravity environments will further understanding of the more complex processes occurring in man. The goal of this program is to develop and support systems and procedures for the application of cellular/molecular techniques to the investigation of space flight relevant biological problems. The projects included in this RTOP are basic research efforts designed to 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.

W91-70243
Ames Research Center, Moffett Field, CA. **199-40-42**
MUSCULOSKELETAL (SUPPORT STRUCTURES AND BIOMINERALIZATION)
E. M. Holton 415-604-5471
(199-28-22; 199-18-22; 199-16-22)

The overall objective of this research program is to determine the role of gravity in musculoskeletal growth and development. Biological species on Earth have developed a musculoskeletal system which provides structural support and a mineral reservoir; both functions are coupled to the age and size of the species. Data from flight and ground research suggest that a biomineralization defect occurs in bones in unloaded limbs of growing rats so that strength no longer correlates with mineral concentration in bone and that atrophy with decreasing strength occurs in postural muscles. To understand how structural tissues are created for support of organisms requires multiple approaches including cellular, invertebrate, and vertebrate systems studied both on Earth and in space. Mineralizing bone cell cultures, muscle cultures, and invertebrate biomineralization will be used to elucidate the genetic, molecular, and cellular mechanisms. Development of matrix in muscle and bone and mineral composition of bone will be characterized in loaded and unloaded bones of growing rats.

W91-70244
Ames Research Center, Moffett Field, CA. **199-40-72**
FLIGHT RESEARCH
R. W. Ballard 415-604-6748

The objectives of this RTOP are to support research directly related to an accepted flight experiment and to support scientific studies to improve existing flight hardware.

W91-70245
Lyndon B. Johnson Space Center, Houston, TX. **199-52-11**
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 interplanetary dust particles stems from their potential for contributing to the elucidation of the cosmic history of the organogenic elements (i.e., H, C, N, O, S, and P) that make up all living systems. Therefore, the study of IDPs will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

W91-70246
Ames Research Center, Moffett Field, CA. **199-52-12**
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-604-5909
(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

W91-70247
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
V. G. Anicich 818-354-2439

The spectrum of Halley had an emission feature at 3.36 microns and the grain composition was high in H, C, N, and O. Grains were the likely source of excess CO, C(+), and CN detected in the coma. A systematic study was undertaken 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. The goal is to understand the carbon budget of the comet and the chemical evolution of the organic components in grains. Systematic studies will be carried out of: (1) the kinetics of binary ices under UV irradiation at T greater than 20 K; and (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. It is well-known that the fundamental molecular vibration frequencies are altered by coupling with the solid-state lattice.

199-52-22

W91-70248
Ames Research Center, Moffett Field, CA.
PREBIOTIC EVOLUTION
S. Chang 415-604-5733
(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

W91-70249
Langley Research Center, Hampton, VA.
PHOTOCHEMISTRY/GEOCHEMISTRY OF THE EARLY EARTH
Joel S. Levine 804-864-5692

Objectives of this RTOP 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, to assess the possibility of life on Mars, and to provide scientific support to NASA's Manned Mars Mission planning activities.

199-52-32

W91-70250
Ames Research Center, Moffett Field, CA.
THE EARLY EVOLUTION OF LIFE
D. J. DesMarais 415-604-3220
(199-52-22)

The objective of this RTOP is to understand the nature and history of primitive organisms and to relate their 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.

199-52-52

W91-70251
Ames Research Center, Moffett Field, CA.
SOLAR SYSTEM EXPLORATION
G. C. Carle 415-604-5765
(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, such as 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).

199-52-82

W91-70252
Ames Research Center, Moffett Field, CA.
EXPLORATION EXOBIOLOGY
D. L. DeVincenzi 415-604-5251
(199-52-52)

The objective of this RTOP is to define exobiology science objectives for the Space Exploration Initiative (SEI) missions to the Moon and Mars, with emphasis on Mars. This will involve determining if Mars harbors an extant or extinct biota or evidence for prebiotic chemical evolution. The approaches of this RTOP will include: programmatically-oriented activities to define exobiology science objectives for SEI missions, and research activities to characterize the physical and chemical environment of Mars, develop Earth models for extant and extinct life on Mars, and study survival of organics under Martian conditions.

W91-70253
Ames Research Center, Moffett Field, CA. **199-55-12**
ADVANCED PROGRAMS IN BIOLOGICAL SYSTEMS RESEARCH
R. D. MacElroy 415-604-5573
(199-52-22; 199-61-12; 199-30-32)

The objectives of the RTOP are two-fold. The first is 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. The second objective is to identify and determine the feasibility of, and to 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.

W91-70254
Ames Research Center, Moffett Field, CA. **199-59-12**
SCIENCE DEFINITION FOR PLANETARY PROTECTION
G. C. Carle 415-604-5765
(199-52-52; 107-20-08; 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 Global Network 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. In addition, it is desirable to develop an experiment to determine the Martian surface redox potential.

W91-70255
Lyndon B. Johnson Space Center, Houston, TX. **199-61-11**
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 Outpost will be one of the first post-Space Station missions undertaken. While the life support systems for Space Station and a Lunar Outpost have similar components, the availability of lunar resources adds a new dimension to a Lunar Outpost CELSS. The objective of this RTOP is to continue and initiate new research in support of a Lunar Outpost CELSS. Three 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; and (3) develop representative lunar mineral and lunar glass simulants for continued investigation and to allow comparability of results among researchers.

W91-70256
Ames Research Center, Moffett Field, CA. **199-61-12**
BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)
R. D. MacElroy 415-604-5573
(199-61-23)

The objective of this RTOP is to support the scientific experiments, the technological investigations, and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of the functions performed by higher plants, algae, microorganisms, physical-chemical processes and mechanical devices for human life support. Of particular interest are the functions that produce potable water, food and oxygen, absorb carbon dioxide and process waste materials in orbit or on planetary surfaces. The goal is to ensure recycling materials by regeneration of consumables 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. The data collected form a science-requirements base for the use of the Controlled Ecological Life Support Systems (CELSS) Projects and the design of experiments to be conducted in space using CELSS/FEAST hardware developed under the Space Biology Initiative.

W91-70257
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **199-61-14**
EVALUATION AND DESIGN OF FERMENTERS FOR MICROGRAVITY OPERATION
G. R. Petersen 818-354-7019

The objectives of this RTOP are to: (1) use sound engineering and scientific approaches to design and build an operational bioreactor system(s) for eventual testing under microgravity conditions (STS missions); (2) obtain operational data on such bioreactor systems as well as on the effect of microgravity on cultured microorganisms; and (3) use ground based experimental analyses of such bioreactor systems to develop flight ready instrumentation. Meeting the needs of microbial and biological processing in microgravity requires development of both production model reactors and research scale reactors. Development of a production model reactor has been the main focus of this effort and ground based models have been built and tested. These phase separated membrane bioreactor (PSMB) models are being examined for configuration, material requirements, and operational requirements. Upon completion of this work, the data will be used to design and build an actual piece of flight hardware. A research 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, morphology; (2) intracellular metabolic effects; and (3) microbial ecological effects such as the intercellular metabolic dependencies found in heterogeneous microbial populations. If resources and time permit, 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.

W91-70258 199-70-00
John F. Kennedy Space Center, Cocoa Beach, FL.
METEOROLOGICAL DATA ARCHIVAL
James R. Nicholson 305-867-2780

The objectives are to permanently capture unique mesometeorological data sets that are in operation at NASA Kennedy Space Center (KSC), process them to insure that they are of research quality, archive the data in easily used standard and universal formats, and provide access to them through the Space Physics Analysis Network (SPAN). The approach is to use existing KSC data base management facilities consisting of VAX 11780 and 11750 computers and peripheral equipment and provide minimal supplemental equipment where needed. The existing equipment supports information management, expert knowledge system projects, planning, and processing of other forms of data.

Astrophysics Mission Operations and Data Analysis

W91-70259 399-18-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIPPARCOS VLBI
R. A. Preston 818-354-4631

The ESA satellite HIPPARCOS will determine the positions, proper motions and trigonometric parallaxes of 100,000 optical stars with unprecedented accuracy. It is planned to tie the HIPPARCOS observations to the JPL Very Long Baseline Interferometer (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 linked to a nearly inertial reference frame, and will result in a common optical/radio high precision celestial reference frame. The HIPPARCOS and VLBI reference frames will be tied together by radio stars which can be positioned directly in both frames. In the last year, an astrometric VLBI observational program has been continued on 12 radio stars, mostly of the RSCVn class of close binaries (approximately 0.001 sec separation), using phase-referencing techniques. Previous observations have also provided significant new information on stellar radio emission mechanisms.

W91-70260 399-30-00
Ames Research Center, Moffett Field, CA.
ASTROPHYSICS MISSION OPERATIONS AND DATA ANALYSIS
J. D. Scargle 415-604-6330

The objective of this RTOP is to optimize the scientific return from programs in observational astronomy, including completed, existing and future NASA astrophysics missions. The approach of this RTOP is to develop innovative data analysis tools for various astrophysical problems, with the goal of making research in astrophysics more efficient through improved access to and management of astronomical data. The two tasks are aimed at crafting new tools for time series analysis and reduction of infrared data, especially from arrays.

Space Physics Theory

W91-70261 431-03-00
Goddard Space Flight Center, Greenbelt, MD.
MHD TURBULENCE, RADIATION PROCESSES AND ACCELERATION
Melvyn L. Goldstein 301-286-7828

The objectives of this RTOP are: (1) to study magnetohydrodynamic (MHD) turbulence, radiation processes, and particle acceleration mechanisms in solar and magnetospheric plasmas; (2) to publish in the scientific literature and to present at professional meetings the significant results of such research; 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.

Space Physics SR&T

W91-70262 432-20-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAGNETOSPHERIC COUPLING
R. Goldstein 818-354-0241

This RTOP comprises three separate tasks: (1) Magnetohydrodynamic (MHD) Disturbances in the Magnetotail (Analysis of rapid changes of magnetic field in the near-Earth magnetotail, using Spacecraft Charging at High Altitude (SCATHA) and International Sun-Earth Explorers (ISEE) data); (2) Cometary Plasma Physics (Analysis of Giotto/Halley comet plasma data for wave processes and energy transport); and (3) Electron Impact Studies (Laboratory studies of electron impact processes of interest for magnetospheric and ionospheric processes).

W91-70263 432-20-00
Goddard Space Flight Center, Greenbelt, MD.
SOLAR WIND-MAGNETOSPHERE COUPLING, MAGNETIC FIELD MODELING, AND MAGNETOTAIL DYNAMICS
James A. Slavin 301-286-5839

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 and to study chaotic aspects of substorm dynamics and dissipation processes. The research approaches involve a combination of data analysis, statistical studies, and chaotic systems modeling. The second task supports data analysis and modeling of the magnetotail structure and dynamics. The approach is to assemble the IMP-8 and ISEE-3 observations during 1982 to 1983 into a single data base and to then perform detailed analyses of the data for a variety of tail substorm phenomena. The third task is to perform global modeling of the Earth's magnetosphere using empirical techniques. The approach has been 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.

W91-70264
Goddard Space Flight Center, Greenbelt, MD. **432-36-03**
PRESERVATION AND ARCHIVING OF EXPLORER SATELLITE DATA
R. A. Hoffman 301-286-7386

The NASA Explorer Project scientists for Interplanetary Monitoring Platform (IMP), Dynamics 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 technical and realistic cost estimates to recover data from old and possibly deteriorated magnetic tapes for subsequent transfer for archival; (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 have been identified, and their dissemination to users. For objectives (1) and (3), candidate data sets from IMP and ISEE were first identified, upon which approaches were developed for the subsequent work. With the diverse formats and time resolutions available, the feasibility of converting the data to a common format and consistent time resolution were investigated. Appropriate investigators are being funded to prepare data for submission to the NSSDC. For objective (2), software was developed to convert the DE tape telemetry data base from Sigma-9 format to optical disks running on DEC VAX computers. Operational procedures were developed to transfer the data.

W91-70265
Goddard Space Flight Center, Greenbelt, MD. **432-48-00**
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 composition, 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, SAR arcs, etc.

Space Physics ATD

W91-70266
Goddard Space Flight Center, Greenbelt, MD. **433-04-00**
SPACE PHYSICS MISSION PLANNING
R. W. Farquhar 301-286-5840

The objectives of this RTOP include development of new trajectory concepts and orbit-control techniques for space physics missions, and utilization of these, along with 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, 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.

W91-70267
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **433-90-00**
SPACE PHYSICS PROGRAM SUPPORT/DETAILEES
P. N. Swanson 818-354-3273

Support will be provided to the Space Physics Division, Office of Space Science and Applications, NASA Headquarters, by the assignment of three detailees, in addition to the continuation of requested studies, participation in project/program reviews, and other activities as directed.

W91-70268
Goddard Space Flight Center, Greenbelt, MD. **433-90-00**
SUPERCOMPUTER SUPPORT
Melvyn L. Goldstein 301-286-7828

The objective of this RTOP is to support the operating budget of the NASA Space and Earth Sciences Computing Center (NSESCC) associated with very large-scale computational support of RTOP related research within the Space Plasma Physics program. In particular, this RTOP supports much of the super-computing needs of research supported by NASA's Space Physics Theory Program. The funding will provide a total allocation of approximately 1000 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 as determined by the RTOP manager in consultation with personnel at NASA Headquarters.

Space Physics Sounding Rocket Research

W91-70269
Goddard Space Flight Center, Greenbelt, MD. **435-11-00**
SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS
R. A. Hoffman 301-286-7386

The objective of this RTOP 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 (30 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.

W91-70270 **435-11-00**
Marshall Space Flight Center, Huntsville, AL.
SPACE PLASMA PHYSICS EXPERIMENTS - MASS SPECTROMETER
C. J. Pollock 205-544-7638

The objectives of this RTOP are threefold. The first objective is to develop the ability to provide low-energy plasma measurements which will completely specify the state of ambient ionospheric plasma, through measurement of the thermal and superthermal electron and ion species three-dimensional distribution functions, f(v). Second processes responsible for the transfer of energy to cold ionospheric plasma constituents, leading to heated or nonthermal ion and electron distributions are observed and identified. Third the geophysical consequences of this energy dissipation, are to be evaluated, particularly regarding ion transport and the ionosphere as a magnetospheric plasma. The single task associated with this RTOP is to provide a tested, calibrated, and flight-ready Superthermal Ion Composition Spectrometer (STICS) for flight onboard the NASA TOPAZ 3 sounding rocket. The launch of this auroral sounding rocket from Poker Flat Research Range in the winter of 1990 to 1991 will be supported.

Radiation and Dynamic Processes

W91-70271 **460-20-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MONITORING GLOBAL SEA LEVEL WITH ALTIMETER TRANSPONDERS
E. J. Christensen 818-354-1992

Spaceborne altimeters measure sea level with a precision of a few centimeters and topographic features on land with a precision of only a few meters. Used in conjunction with altimeter transponders, the vertical height of fiducial sites on land can be measured with accuracies comparable to those obtained at sea. Therefore, altimeter transponders provide the unique opportunity to obtain internally consistent sets of high precision vertical height measurements taken on land and at sea. That is, selected fiducial sites on land can be tied to global sea level data sets produced by missions such as TOPEX/POSEIDON, ERS-1, and SALT. Altimeter measurements are generally gathered along a repeated groundtrack where the duration of the repeat cycle is typically 10, 17 or 35 days, depending on the mission and mission phase. Owing to the random nature of the measurements, long term vertical motion of a specific site can be observed with a high degree of confidence. Therefore, altimeter transponders can be used to address questions pertaining to change in global sea level, motion of ice sheets, orogenic uplift, and isostatic adjustment. For these applications, it is proposed that the transponders be tied to the fundamental reference frame defined by the quasars using Very Long Base Interferometer (VLBI), and to the earth's center using the Global Positioning System (GPS) and satellite laser ranging. The intent is to remove the word 'relative' from the field of relative surface leveling. It is proposed here that dual frequency L1/L2 GPS receivers collocated with altimeter transponders be deployed along the TOPEX/POSEIDON groundtrack. Through differential GPS geodetic positioning, these sites will serve as control points for the network. The altimeter data, combined with the radial position of the orbit, will provide a spatially continuous record of sea level relative to the land based fiducial sites at five or ten day intervals. The orbit will be determined using GPS, laser, and perhaps Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) tracking data. The tracking and transponder systems enable the tie of global sea level to the fundamental reference frame and to the earth's center. Transponders can also be used to detect and measure episodical changes in the vertical due to earthquakes and volcanic eruption. Another important application is to deploy altimeter transponders on platforms at sea for calibrating the electromagnetic bias and, in the case of dual frequency altimetry, verify corrections for ionospheric delay. Transponders also lend themselves to removing once per orbit radial errors encountered in precision orbit determination.

W91-70272 **460-20-45**
Goddard Space Flight Center, Greenbelt, MD.
RETRIEVALS OF CLOUD PHYSICS PARAMETERS
J. R. Bates 301-286-7482

The objective of this task is to continue the development, improvement, and verification of the techniques utilized in the derivation of global precipitation using a combination of visable, infrared and microwave data acquired from the High Resolution Infrared Sounder 2/Microwave Sounding Unit (HIRS2/MSU).

W91-70273 **460-21-17**
Goddard Space Flight Center, Greenbelt, MD.
ATMOSPHERIC STATE SOUNDING
Franco Einaudi 301-286-6786

The objectives of this RTOP are (1) to gain an understanding of the role of stratospheric-tropospheric (ST) profilers in improving the understanding of the atmospheric state; and (2) develop and adapt techniques to sound the atmosphere from geosynchronous orbit for use with GOES I-M. Weakly nonlinear theory of solitary waves will be developed to include critical layers in the shear flow to understand atmospheric ducting of large-amplitude gravity waves using Flatland ST radar, Urbana, IL, to identify gravity wave disturbances and convective cells. The capability to use the University of Wisconsin GOES-I sounding technique and initiation of case studies is being developed at GSFC.

W91-70274 **460-22-83**
Goddard Space Flight Center, Greenbelt, MD.
IN SITU/REMOTE INSTRUMENT ANALYSIS AND VERIFICATION
F. J. Schmidlin 804-824-1618

The purpose is to enhance the existing knowledge of upper-air instrument precision and accuracy. Archived and new data sets will be used to investigate radiosonde performance and behavior. Temperature corrections under development for the U.S. standard radiosonde's sensor will be extended to other sensor designs and tested in Hemispheric Analysis with the cooperation of the National Meteorological Center (NMC) and the European Centre for Medium Weather Forecasts (ECMWF). An effort will be initiated to fabricate and test extremely small-diameter (approximately 0.05 mm) thermocouples; thermocouples are expected to provide highly accurate measurements. Satellite data from Tiros Operational Vertical Sounder (TOVS) and radiosonde data will be compared over a spectrum of atmospheric wavelengths and retrieval algorithm coefficient errors resulting from errors of radiosonde temperatures will be deduced. An overview of relative humidity sensors important for global studies of water vapor variability and climatology will be provided. The approach will be to provide the expertise to test and evaluate various radiosonde systems and techniques using the unique telemetry, radar and computing capability located at 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 will be improved for the rod thermistor of the U.S. standard radiosonde and up-to-date adjustments will be developed for those instruments compared in the WMO International Radiosonde Intercomparison. There is evidence that radiational errors of radiosondes differ at different sites during different seasons. Theory predicts that the variation of radiational errors is due to differing environmental background long-wave emission. The long-wave error seems to be sensitive to clouds and emission from the atmosphere. A new radiosonde type will permit eight separate sensor designs to be tested simultaneously using improved digital transmission and recording techniques. This system will permit tests to be conducted much more efficiently than in the past. The recent evidence that radiational errors vary with background environmental conditions will require additional test data to be gathered at remote sites in order to find the extremes of the error. The ECMWF and NMC have both expressed a desire to use the final corrections when they are available. Radiosonde measurements are used to ground-truth satellite retrieved temperatures. Corrected and routine 'uncorrected' radiosonde data will be used in comparing these data to enable an estimate of satellite retrieval error resulting from radiosonde errors to be quantified more accurately.

W91-70275 **460-23-53**
Goddard Space Flight Center, Greenbelt, MD.
HYDROLOGICAL AND MESOSCALE ATMOSPHERIC PROCESSES RESEARCH
Franco Einaudi 301-286-6786

The objective of this RTOP is to understand the atmospheric and hydrologic processes associated with tropical and extratropical storms over oceanic regions, cold-air outbreaks and coastal cyclogenesis, slantwise convection, severe thunderstorms, continental mesoscale convective systems, drylines, and continental and oceanic rainfall. The approach is to develop data assimilation schemes, modify algorithms, analyze specialized data sets, modify and upgrade models, participate in data collection experiments, test models, and interpret results.

W91-70276 **460-26-08**
Goddard Space Flight Center, Greenbelt, MD.
SCIENTIFIC PROGRAM SUPPORT AND SUPPORT FOR THE HIGH SPEED VECTOR PROCESSOR
Franco Einaudi 301-286-6786

The objective is to provide funding for support activities of benefit to the Severe Storms Branch as a whole and for the use of the high speed vector processor.

W91-70277 **460-96-00**
Langley Research Center, Hampton, VA.
RADIATION, DYNAMICS AND HYDROLOGY; RADIATION AND DYNAMICS PROCESSES
Edwin F. Harrison 804-864-5663

The objectives of this RTOP are to conduct regional studies of aerosols, water vapor, and cloud processes and to develop measurement techniques for observing radiative and hydrological properties of the atmosphere. The following approach will be used: (1) Continue 48-inch ground based Lidar measurements to extend the climatology of aerosol distributions and cloud measurements in support of the First ISCCP Regional Experiment (FIRE) and ECLIPS Programs; (2) Conduct analyses of satellite data (GOES, LANDSAT, and AVHRR) and surface observations to define spatial, seasonal, and diurnal variation of cloud radiative properties as part of the FIRE investigations; (3) Combine satellite, surface and airborne measurements with theoretical studies to investigate cirrus and marine stratocumulus cloud systems for Project FIRE; (4) Develop and test catalyst for long life, closed cycle, carbon dioxide Laser operations for Laser Atmospheric Wind Sounder (LAWS); and (5) Develop and flight test an Alexandrite Differential Absorption Lidar (DAIL) system for water vapor measurements.

Hydrologic Processes

W91-70278 **461-11-15**
Goddard Space Flight Center, Greenbelt, MD.
WALLOPS GROUP COMPUTING
W. B. Krabill 804-824-1417

This program will provide the necessary computer tools to support the team of scientists and engineers that analyze data collected by the Airborne Oceanographic Lidar (AOL), the Surface Contouring Radar (SCR), Multi-Mode Airborne Radar Altimeter (MARA), and the airborne Global Positioning System (GPS) receivers at the Wallops Flight Facility. The proposed activities will result in the maintenance of the computer laboratory at a level which is responsive to the needs of the engineers and investigators. This program would provide a part-time system analyst to structure and maintain the network of Sun workstations. In addition, the proposed activities would result in the purchase of software/hardware components to enhance and improve the overall efficiency of the network.

W91-70279 **461-31-05**
Goddard Space Flight Center, Greenbelt, MD.
AIR-SEA INTERACTION STUDIES
Frederick C. Jackson 301-286-5380

The objective is to develop and apply microwave instrumentation for the remote sensing of oceanic processes and air-sea and ocean-ice interactions. Airborne instrument development programs aim at advancing the state of the art in airborne and satellite active and passive remote sensing of the sea surface for waves, currents, air-sea fluxes, and water bulk properties. These programs are supported by laboratory and theoretical studies of surface wave dynamics and statistics and of electromagnetic wave/surface wave interactions.

W91-70280 **461-54-50**
Goddard Space Flight Center, Greenbelt, MD.
CONVECTIVE RAINFALL ESTIMATION
Franco Einaudi 301-286-6786

The objective of this RTOP is to investigate precipitation processes in mesoscale convective systems through the use of remote sensors. The approach is to use radiative transfer and cloud dynamics models to study relations observed at microwave wavelengths; use area-time-integral technique on satellite IR data to estimate convective rain; and participate in the CAPE experiment.

W91-70281 **461-60-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROWAVE PROCESS STUDIES OF SEA ICE PROPERTIES
M. R. Drinkwater 818-354-8189

We will focus on establishing interrelationships between microwave frequency instrument measured quantities and specific geophysical parameters of three scientifically important ice forms; namely thin, snow covered, and old sea ice. The central theme of this process study is to use existing synthetic aperture radar (SAR) and airborne multichannel microwave radiometer (AMMR) datasets in conjunction with in-situ snow and ice data and theoretical polarimetric models to: (1) characterize the polarimetric microwave response to key ice property variations; (2) refine and validate recent models in order to simulate scattering and emission characteristics of these ice forms; and (3) derive methods for inversion from signatures to ice properties using SAR image data. Existing techniques for coregistering simultaneous AMMR and SAR datasets are to be used to extract quantitative data from the corresponding active and passive microwave behavior of each ice form. The development of tools is envisaged which will enable visualization and quantitative analysis of multi-polarization data collected in March 1988 in the Beaufort, Chukchi and Bering Seas by the JPL multifrequency SAR and GSFC multifrequency radiometer. Polarization synthesis will be implemented to document SAR polarization signatures of these key ice forms under varying surface conditions and radiometric characteristics. Results from parametric modelling predictions incorporating similar variability in ice properties will be compared with these signatures in order to validate scattering and emission theory used in the models. Techniques of inverting signatures will then be tested using a new airborne polarimeter and ERS-1 SAR dataset acquired during flights planned over the Southern Ocean in 1992. Results will be checked using surface data collected during simultaneous AnZone coordinated field experiments in the Weddell Sea. The outcome of this proposed work is a capability, using SAR data, to infer critical ice property information for the operational derivation of surface fluxes of heat, salt and mass in the polar oceans.

461-61-03

W91-70282
Goddard Space Flight Center, Greenbelt, MD.
GPS/LASER INTEGRATION
W. B. Krabill 804-824-1417

The goal of this program is to develop and refine the combination of airborne Global Positioning System (GPS) positioning and laser ranging technology to an accuracy better than 10 cm, and to apply this technology to acquire surveys of the elevation (topographic height) of polar glacier surfaces at the sub-decimeter level. Repeated surveys in ensuing years would yield a determination of net gain or loss of ice volume over a wide area. Knowledge of the ice budget in polar glaciers will provide an indirect measure of sea level changes and a clear indication of trends in world climate. The availability of this information is critical to inferring the future effects of increased CO2 and methane on the global temperature field. This program combines established airborne laser ranging technology, both profiling and scanning, with a precise application of the DoD's GPS. The primary airborne laser system used in this program is the Airborne Oceanographic Lidar (AOL) based at NASA Wallops Flight Facility. The precise ranging capability of the AOL to meet the required tolerances necessary for the glacier surveying application has been previously demonstrated. The technical developments necessary for the success of this research lies in developing the GPS carrier phase tracking technology and in the navigation of the aircraft using a GPS receiver.

461-62-02

W91-70283
Goddard Space Flight Center, Greenbelt, MD.
SAR STUDIES OF ICE SHEETS
R. A. Bindschadler 301-286-7611

The objective of this research is to demonstrate and develop the capability to monitor the hydrologic cycle on ice sheets by identifying and mapping the different snow facies.

Ecosystem Processes

462-24-00

W91-70284
Goddard Space Flight Center, Greenbelt, MD.
DECADAL VARIABILITY IN GCMS
R. Koster 301-286-7061

In this project the long term variability of the global hydrological cycle is studied through numerical experiments. One of the objectives is to estimate the natural variability internal to the land-atmosphere system and to distinguish it from that arising from external sources, such as changing sea-surface temperature (SST). The sensitivity of the hydrological cycle to external perturbations, such as those caused by changing land-use practices is also examined. This work should help identify the land-surface properties that are important in the monitoring of long term climate change. The approach is to couple an atmospheric general circulation model (GCM) designed for long-term climate simulation to a fairly sophisticated land surface model (LSM) that explicitly includes the effects of vegetation on the surface energy balance. The LSM is largely a simplified version of the SiB model, structured efficiently enough to allow decadal simulations. Remotely-sensed data will help establish model boundary conditions and evaluate model output. Numerous simulations with the coupled models will then isolate the sources of natural climate variability (e.g., by deactivating variability in SST and soil moistures in separate simulations) and also investigate climate response to prescribed anthropogenic change.

462-24-00

W91-70285
Goddard Space Flight Center, Greenbelt, MD.
SNOW PACK PROPERTIES
A. T. C. Chang 301-286-8997

Different types of studies will be performed with an eye to improving the capability to use microwave remote sensing for monitoring snowpacks. Controlled experiments, possible with a tower-mounted system of microwave sensors, and coincident detailed snow observations are needed to better specify the microwave response to various snow properties and to refine radiative transfer models. Additionally, microwave studies need to be carried out at the scale of a satellite footprint. Regional studies provide an opportunity, at a suitable scale, to calibrate and compare satellite measurements with aircraft and ground-based measurement so as to facilitate algorithm development and to validate the spaceborne observations. Field studies are planned for Mammouth Mountain, California and Maine for the 1990 to 1991 snow season. Hand held radiometer at 35 GHz and possible 90 GHz radiometer will be utilized to observe the angular responses for different snowpacks. Concurrent with the radiometer measurements, snow wetness, temperature, stratigraphy, depth, density, and microstructure will be collected. This information will be used to test the dense media radiative transfer program. In addition, snow reflectance will be studied using the SE-590 spectrometer in order to develop an improved understanding of the bidirectional reflectance of snow. The Scanning Multichannel Microwave Radiometer (SMMR) and Special Sensor Microwave/Imager (SSM/I) derived snow parameters in the Colorado River basin, north-central Alaska, Canadian plains and western China will be undertaken in order to develop regional snow retrieval algorithms for different physicographic and surface covers.

462-24-00

W91-70286
Goddard Space Flight Center, Greenbelt, MD.
OPTIMAL USE OF ACTIVE/PASSIVE MICROWAVE SENSORS IN RETRIEVING SOIL MOISTURE PROPERTIES OF GRASSLANDS
P. ONeill 301-286-8273

The objective of this RTOP is to examine the use of active and passive microwave remote sensing data to estimate soil moisture profiles of grasslands. The proposed research will focus on the L- and C-band sensors and will seek to: (1) investigate the effect of surface burn treatment (removal of thatch layer) on the microwave emission and polarimetric backscattering coefficients (involving the analysis of SAR (JPL) and PBMR data sets obtained during the FIFE experiment over the Konza Prairie grassland (1989) and the MAC-HYDRO experiment (including ESTAR) over Mahantango watershed in Pennsylvania (1990)); (2) conduct controlled measurements using truck-mounted radar and radiometers at the Beltsville test sites to verify and calibrate emission and backscattering models for grass canopies; and (3) determine optimum conditions to combine active and passive measurements for large scale soil moisture estimation. A physically based model has been developed to calculate polarimetric backscattering coefficients and brightness temperatures for grass canopies. A field experiment is scheduled for Aug. 1990 and 1991 at Beltsville sites using truck-mounted radar and radiometers. The measurements will include bare soil, a grass field planted the current year (no thatch) and a thatched grass field that has been developed over the past two years. Analysis of First ISLSCP Field Experiment (FIFE) 89 and MAC-HYDRO data sets will be undertaken in conjunction with the model predictions. The objective of this addendum is to include the ground observations of a 37 GHz truck-mounted radiometer as part of the controlled measurements proposed in this RTOP. These measurements which will be used to validate a radiative transfer model are coupled with a comparative study of global satellite observations at 37 GHz and visible and invisible reflectances. These measurements include: (1) horizontally and vertically polarized brightness temperatures at several angles at 37 GHz over bare soil, grass and soybeans; (2) biophysical measurements including leaf area index, soil and canopy moisture content and fractional ground cover; and (3) limited number of observations by SE-590 Spectrometer.

W91-70287
Langley Research Center, Hampton, VA. **462-24-01**
ECOSYSTEM DYNAMICS
James M. Hoell, Jr. 804-864-5826

The objective of this RTOP is to develop an understanding of the physical transport processes associated with biosphere-atmospheric interactions in the high latitude terrestrial ecosystems. The approach for achieving this objective will consist of micrometeorological measurements from ground-based towers coordinated with the measurement of the flux of selected chemical species. In particular, micrometeorological measurements acquired during the joint U.S./Canadian Northern Wetlands Project (e.g., GTE/ABLE-3B) will be analyzed to define the transport processes in a subarctic boreal woodlands and peatlands ecosystem.

W91-70288
Goddard Space Flight Center, Greenbelt, MD. **462-26-00**
SYNTHETIC APERTURE L-BAND RADIOMETER
David M. LeVine 301-286-8059

The measurement of soil moisture from space requires large antennas in orbit because of the long wavelengths needed to penetrate the vegetation canopy. For example, to obtain 10 km spatial resolution from the Earth observing system (Eos) orbit requires an antenna 20 meters on a side. However, it is possible to create these large antenna apertures synthetically using pairs of small antennas and signal processing. The technique is called aperture synthesis and involves making measurements with pairs at many different antenna spacings. This research is to develop the technique of aperture synthesis for application to the measurement of soil moisture by building an aircraft prototype instrument operating at L-band (1.4 GHz).

W91-70289
Goddard Space Flight Center, Greenbelt, MD. **462-26-00**
HYDROLOGY PROGRAM SUPPORT
D. K. Hall 301-286-6892

The objective of this RTOP is to provide funding for support activities of benefit to the branch as a whole without impacting other elements of the GSFC Hydrology program. It provides funding for the scientific visitor program through a university contract, and administrative support related to travel for scientific visitors. Funding will also be used for graduate student stipend and for graduate student travel. In addition, this will also provide funding for maintenance of aging equipment in the branch's computer lab, and map and equipment lab.

W91-70290
Goddard Space Flight Center, Greenbelt, MD. **462-31-00**
FIFE (FIRST ISLSCP FIELD EXPERIMENT)
Forrest G. Hall 301-286-2974

The objectives of this RTOP are to better understand (1) 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) how the relationships which express these controls scale from a point to an area level; and (3) the use of satellite remote sensing to monitor the components of the surface energy budget. The approach is to acquire simultaneous satellite (AVHRR, SPOT, LANDSAT, etc.) aircraft (spectral material and energy flux through the atmospheric boundary layer) and surface observations of radiometric, atmospheric, meteorological, hydrological and biophysical parameters of vegetation and soil at sufficient temporal and spatial resolution and over a large enough area to permit proper comparison of satellite derived quantities with actual surface conditions.

W91-70291
Goddard Space Flight Center, Greenbelt, MD. **462-32-00**
OBSERVATIONS AND MODELING OF AIR-LAND SURFACE INTERACTIONS
P. J. Wetzel 301-286-8576

The objective of this RTOP is twofold. The first purpose is to employ numerical modeling to examine the role of land surface characteristics on atmospheric processes. Two processes are the subject of specific focus: on the short time scale the formation of boundary layer cloudiness in response to vegetation and soil moisture, and on the longer time scale, the effect of surface characteristics on the possible exacerbation of the 1988 midwestern drought. The second purpose is to experiment with methods of incorporating new remotely sensed information into numerical models. This includes finding ways to combine microwave Special Sensor Microwave/Imager (SSM/I) data, Advanced Very High Resolution Radiometer (AVHRR) data, and/or the products of GOES vis/IR rain estimation techniques to improve upon current retrievals of soil moisture and key vegetation properties.

W91-70292
Ames Research Center, Moffett Field, CA. **462-40-00**
RESEARCH IN FRESHWATER ECOSYSTEMS
D. L. Peterson 415-604-5899

The objective of this research is to acquire a predictive understanding of freshwater ecosystems and resources based on the advanced application of NASA technology in biological sciences, remote sensing, information systems, and mechanistic and radiative modeling. The goal is to be able to understand how freshwater ecosystems and the watersheds in which they are located can influence global and regional climatic patterns, how they respond to changes in these climatic driving forces, and what characteristics of freshwater systems may help elucidate and define the evidence for climate change through sensitive indicator properties and organisms. The approach will be to combine methods of advanced biological techniques in trace gas measurement, limnological sciences, organic chemistry, and spectroscopy with planned Earth Observing System (EOS), new and optimized remote sensing techniques specialized for sensing the unique properties of freshwater systems and their surrounding disturbed watershed regions into information systems designed to manage the interdisciplinary data in ways most responsive to hydrological basins for input to mechanistic and radiative transfer models for simulating the processes, interactions and regulation occurring in these systems. These techniques will be applied to freshwater ecosystems across a range of disturbance scenarios. All research will be collaborative with other agencies and universities.

W91-70293
Ames Research Center, Moffett Field, CA. **462-40-00**
SPATIAL AND TEMPORAL DISTRIBUTION OF BIOMASS COMBUSTION ON REGIONAL SCALES: AN ECOLOGICAL PERSPECTIVE
J. A. Brass 415-604-3299
(199-30-72)

The objectives of this research are to: (1) develop an understanding of the spatial and temporal frequencies of fire events on regional scales; (2) develop a statistical model to explain the spatial and temporal frequency of fire; and (3) estimate fire occurrence and extent on a regional basis using modeling and

Geographic Information System (GIS) technology. The approach is to develop a statistic model of fire frequency using historical remote sensing imagery documenting fire occurrence and extent within and between western U.S. ecosystems. Using existing western U.S. data bases, each fire occurrence will be characterized by soil type, vegetation, land use, and fire intensity. Modeled fired occurrence will be validated by an existing U.S. Forest Service data base which documents all fires in the western U.S. The methodology developed here will be extended to all of North America (Canada, U.S., Mexico).

W91-70294 **462-40-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ERS-1 DATA ANALYSIS - FORESTS
J. B. Way 818-354-1835

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 enhance or subdue certain components of the radar backscatter. The primary objective of this effort is to collect, calibrate, and analyze ERS-1 image data to be used in studying temporal change (phenologic and environmental) in forest ecosystems. A related RTOP under Dr. Diane Wickland's program addresses the collection of associated ground truth and modeling of the canopy data to predict multi-seasonal radar backscatter signatures. To address the above questions, we are using multi-season ERS-1 Synthetic Aperture Radar (SAR) data sets of the Bonanza Creek Experimental Forest in Alaska, the Duke Forest and the 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. To date using the airborne SAR, freeze-thaw conditions have been obtained in Alaska, spring and summer conditions have been obtained over Duke, and a winter-spring data set has been acquired over Michigan with plans for a summer data set in July 1990. Results of the analysis of these data indicate .2 to 7 dB changes may be observed due to changing environmental conditions.

W91-70295 **462-43-00**
Ames Research Center, Moffett Field, CA.
AN INDEPENDENT SPECTRORADIOMETRIC CALIBRATION FACILITY FOR THE EOS ERA
R. C. Wrigley 415-604-6060

The objective of this work is to create and maintain an independent, credible, calibration facility at Ames Research Center for the Earth Observing System (EOS) era for spectroradiometric calibration and characterization of aircraft remote sensing instruments and spectroradiometric field instruments both for Ames' investigators and for EOS (or other NASA) investigators. The approach is to build upon the current facilities of the Science and Applications Aircraft Division and the Earth System Science Division by providing independent capabilities for spectral and radiometric measurement and verification in terms of special equipment and knowledgeable personnel.

W91-70296 **462-43-70**
Goddard Space Flight Center, Greenbelt, MD.
FOREST ECOSYSTEM DYNAMICS
Darrel L. Williams 301-286-8860

The overall objective of the research is to use forest pattern and process models, soil models, and radiative transfer models, combined with ground, airborne, and satellite observations to understand the dynamics of boreal forest ecosystem evolution over a variety of temporal and spatial scales. The approach involves two major tasks: the synthesis and organization of available knowledge of forest ecosystem dynamics into a comprehensive modeling framework, and the classical problem of appropriately scaling up the knowledge of ecosystem processes, moving 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.

W91-70297 **462-61-00**
Goddard Space Flight Center, Greenbelt, MD.
CALIBRATION OF AVHRR VIS/NIR
Brent N. Holben 301-286-2975

The objective of this RTOP is to provide a radiometric calibration of the NOAA Advanced Very High Resolution Radiometer (AVHRR) visible and near-IR systems. Two basic approaches will be applied to understand apparent spectral dependent sensor response observed to date. The first approach uses molecular scattering over the oceans to provide a known (modeled) radiance to the sensor in the visible band. The spectral independence of sun glint will be used to transfer the calibration to the near-IR band. Deep space views will be used as the zero radiance values and assume linearity. These provide an absolute calibration which emphasize calibration of targets which are brighter at short wavelengths. The second approach will be the desert method. This method relies on the reflective constancy of several desert sites through the lifetime of the satellites. The method is wavelength independent, has high precision but provides only a relative calibration. An adaption of the desert method is to examine wavelength dependent targets which are constant with time. Several full canopy forests will be examined to achieve this.

W91-70298 **462-61-00**
Goddard Space Flight Center, Greenbelt, MD.
ASAS OPERATIONS
James R. Irons 301-286-8978

The Advanced Solid-State Array Spectroradiometer (ASAS) is an airborne imaging spectroradiometer capable of acquiring digital image data from multiple view directions. The goal of this RTOP is to better support the scientific objectives of terrestrial ecosystem field experiments and Earth observing system (Eos) sensor system development by improving the ASAS data acquisition and processing systems. The technical objectives are to: (1) expedite data processing and improve data quality control; (2) extend the maximum view zenith angle and provide for aircraft yaw compensation; and (3) improve performance and reliability of the sensor system. The approach is to develop a dedicated data processing system to expedite processing and improve quality assessment; design and fabricate a new aircraft mounting bracket for view angle extension and yaw compensation; and replace the sensor detector array to improve reliability.

Biogeochemical Processes

W91-70299 **463-11-14**
Goddard Space Flight Center, Greenbelt, MD.
AIRBORNE OCEANOGRAPHIC LIDAR (AOL)
F. E. Hoge 804-824-1567

The primary objectives of this RTOP are to continue the scientific and instrument research, development, and applications of the NASA/GSFC Airborne Oceanographic Lidar (AOL) leading to improved understanding of global biogeochemical cycling using both active and passive measurements of phytoplankton chlorophyll, phycoerythrin, and phycocyanin pigment and dissolved organic matter. Our approach is to focus efforts upon (1) continued improvement of the airborne pulsed laser measurement of subsurface scattering layers using the AOL; (2) direct application of active-passive correlation spectroscopy (APCS) to AOL data for advanced ocean color satellite sensor band selection and algorithm development; and (3) continued cooperative field investigations with widely-recognized oceanographic institutions, government laboratories, and field centers. Specifically, this RTOP will (1) improve the temporal/depth-resolved electro-optical components of the AOL to allow the detection and measurement of particulate volumetric backscatter over a wide range of signal levels; (2) engage in Japan/U.S. cooperative airborne test of new gated microchannel plate/photomultiplier tube (MCP/PMT) technology within the AOL to improve the scattering layer measurement capability; (3) continue interagency cooperative oceanographic field investigations such as the Joint Global Ocean Flux Study (JGOFS), Office of Naval Research's (ONR) Marine Light Mixed Layer (MLML) investigations; and (4) conduct ocean color experiments using the dual active/passive modes of the AOL such as active (lidar) validation of passive ocean color in-water algorithms especially as they may relate to planned Earth Observing System/Moderate-Resolution Imaging Spectrometer (EOS/MODIS) and Sea-viewing Wide-Field Sensor (SeaWiFS) satellite sensors.

W91-70300 **463-75-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGING SPECTROMETER OPERATIONS
R. Green 818-354-9136

Objectives are to support the activities to routinely acquire, calibrate and distribute data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) for approximately 30 scientific investigators in FY-91. AVIRIS measures the total spectral radiance incident at the sensor in 224 channels with nominally 10 nm spectral sampling and 10 nm spectral response functions Full Width Half Maximum (FWHM) from 400 to 2450 nm in the electro magnetic spectrum. Data from these channels are acquired at nominally 20 by 20 m spatial resolution with an 11 km by up to 100 km image extent. The specific objectives are: (1) science operations management, science requirement verification, in-flight validation and/or calibration and science community liaison; (2) flight season planning, launch site experiment coordination and data acquisition verification; (3) sensor calibration (spectral, radiometric, and geometric), operations and maintenance; (4) data archival, performance monitoring, calibration and retrieval as well as investigator support; (5) upgrade of the data facility computer hardware for timely distribution of AVIRIS data to science investigators; (6) development of the second version of the Spectral Analysis Manager (SPAM II) for quantitative radiative transfer based analysis of AVIRIS measured total spectral radiance; and (7) operation, calibration, and maintenance of the Portable Instantaneous Display and Analysis Spectrometer (PIDAS) for NASA investigators. Overall operations management is provided by the experiment scientist with an emphasis on verification of the science requirements performance and calibration. The experiment coordinator plans the flight season, communicates data acquisition status to the investigator, verifies the data acquired, and ships the data tape. AVIRIS instrument calibration, operations, and maintenance is fulfilled by the engineering team. Data archival, quality monitoring, calibration, and retrieval is addressed with the data facility hardware/software maintenance, calibration and operator personnel. SPAM II development progresses through programmer implementation of science requirements. PIDAS is operated, calibrated, and maintained with science and engineering support.

Atmospheric Processes

W91-70301 **464-10-00**
Goddard Space Flight Center, Greenbelt, MD.
A PORTABLE INTERCOMPARISON CAPABILITY IN SUPPORT OF THE NETWORK FOR THE DETECTION OF STRATOSPHERIC CHANGE
C. L. Parsons 804-824-1390

Ozone trend detection is a difficult, tedious business. The processes believed to be important to other mechanisms of ozone depletion involve long time spans. The diffusion of chlorocarbons and other pollutant species from their sources at the surface to the stratosphere requires a period of years, for example. The monitoring of changes in the ozone amount must extend over decades. The design, development, and maintenance of an adequate network of instrumentation to accomplish monitoring over this length of time is difficult. Like other earth science issues, ozone depletion monitoring must be addressed on a global scale. The Network for the Detection of Stratospheric Change (NDSC) is being designed and developed to monitor changes in the total amount and the vertical profile of ozone on a global basis and for decades. A small number of primary and secondary stations will comprise the NDSC with an array of instrumentation installed at each site. Ultraviolet lidars, millimeter wave microwave sounders, total ozone spectrophotometers, infrared spectrometers, and balloon-borne in-situ ozone profiling sensors are being considered for the instrument complement. The multiplicity of sensors at each site will facilitate intercomparisons at each location, an essential attribute for the NDSC. To intercompare the instruments at different sites and to monitor ozone at non-network sites as required, a mobile instrument package will be necessary. This RTOP addresses the development of this mobile capability, its testing, and its use within the NDSC. The Correlative Measurements Project at the Goddard Space Flight Center (GSFC) has been in the business of intercomparing ozone data from in-situ profilers and ground-based ultraviolet spectrometers with satellite instrumentation since 1982. Intercomparison campaigns have been conducted at the GSFC Wallops Flight Facility (WFF); Palestine, Texas; Natal, Brazil; and at Pt. Mugu, California. The latter campaign supported the development of the NDSC lidar and microwave sounder instrumentation. This experience uniquely qualifies the Correlative Measurements Project team for the mobile intercomparison role in the Network. Some modifications in the Project's instrumentation complement are necessary to equip the team for this new intercomparison activity. This RTOP describes the changes and an implementation plan for supporting the NDSC.

W91-70302 **464-11-02**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - LIDAR EXPERIMENT
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 pressure, temperature, and ozone concentration. The approach will be development and flight of balloon-borne spectroscopic sensors.

W91-70303 **464-12-03**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - FIELD MEASUREMENTS
James E. Mentall 301-286-8959

The objectives of this RTOP are to: (1) determine the specific local chemical and physical interactions in the atmosphere by a combination of theoretical studies and coordinated in-situ measurement campaigns from rocket and balloon platforms; (2) investigate the variations and perturbations of the chemical and physical state of the atmosphere, i.e., variations with altitude, solar conditions, season, latitude, and perturbations from volcanoes, tropical storms, industrial and agricultural activity; and (3) develop and calibrate selected instruments for local and remote investigations of the atmosphere. The approach will be to: (1) develop a balloon-borne Michelson interferometer and measure the concentrations and diurnal variations of trace stratospheric species; (2) develop a pointed spectrometer system and measure the solar photon flux within the stratosphere; (3) perform multi-instrument, coordinated measurements on minor species in the stratosphere; and (4) develop photochemical models to compare experimental results with theoretical predictions.

W91-70304 **464-13-17**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - OZONE GROUND STATION
T. J. McGee 301-286-5645

The objective 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.

W91-70305 **464-13-22**
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 at the Naval Research Laboratory; the 110 GHz ozone radiometer at the Millitech Corporation. These are prototype instruments which are based on proven designs but are individually made for this installation. The TMO station facilities have been designed and constructed by JPL as part of this task. TMO provides 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 from off-site locations through a modem accessible local area network. The two TMO support containers for the instruments have been completed. The ozone instrument was operated in July 1989 for the O3 intercomparison measurements. JPL continued to operate this instrument during the fall of 1989 until December, when it was shipped back to Millitech for repairs and improvements. The O3 instrument was returned to TMO in April 1990 and is now operating on a continuing basis. The water vapor instrument is now scheduled for installation in July 1990. JPL personnel provide support for the installation, operation, and maintenance of these radiometer systems.

W91-70306 **464-15-01**
Goddard Space Flight Center, Greenbelt, MD.
ROCKET MEASUREMENTS OF THE UPPER ATMOSPHERE AND UV FLUX
James E. Mentall 301-286-8959

The objective of this RTOP is to improve our understanding of mesospheric and stratospheric chemistry by measuring the composition and temperature of the upper atmosphere as well as the solar ultraviolet (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.

W91-70307 **464-20-00**
Goddard Space Flight Center, Greenbelt, MD.
ECC HIGH-ALTITUDE CALIBRATION CORRECTIONS
A. L. Torres 804-824-1553

The objective of this RTOP is to continue a study of error sources in the Electrochemical Concentration Cell (ECC) ozonesonde under simulated high altitude conditions, and continue a study of long term trends in depth and vertical extent of stratospheric ozone depletion over Antarctica. A laboratory based flight simulator, which duplicates typical atmospheric profiles of ozone and pressure, will be used to study factors contributing to the precision and accuracy of ozonesondes at high altitudes. Particular emphasis will be placed on resolving differences in the way different users correct for altitude-dependent changes in background current and in sampling pump efficiencies for the ECC ozonesonde. The fifth in an annual series of ozonesonde soundings will be conducted from Palmer Station, Antarctica, during the austral spring of 1991. These soundings will provide detailed vertical ozone and temperature profiles during the period of ozone depletion.

W91-70308 **464-20-00**
Goddard Space Flight Center, Greenbelt, MD.
IMPACT OF FORECAST MODEL MODIFICATIONS ON ATMOSPHERIC DIAGNOSTICS
J. R. Bates 301-286-7482

The objective is to diagnose large scale atmospheric behavior while accessing the impact of analysis-forecast system modifications on the GLA general circulation model. The effect of the model's horizontal resolution on systematic errors will be studied with the spectral height tendency equation. Diabatic heating components and the energetics of the atmosphere, as well as surface stresses and the momentum budget of the atmosphere, will be examined.

W91-70309 **464-21-02**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE - REACTION RATE AND OPTICAL MEASUREMENTS
Louis J. Stief 301-286-7529

The objective 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.

W91-70310 **464-23-02**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE - LABORATORY MEASUREMENTS
T. J. McGee 301-286-5645

The objectives of this RTOP are (1) to support ongoing light detection and ranging device (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) measure UV Raman scattering 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.

W91-70311 **464-41-02**
Goddard Space Flight Center, Greenbelt, MD.
ASSESSMENT AND COORDINATION
Richard S. Stolarski 301-286-9111

This effort will form committees of leading scientists to evaluate the state of knowledge concerning ozone trends and will prepare reports summarizing the present knowledge. The Ozone Trends Panel Report has been prepared, and the report of the International Ozone Trends Panel-1988, World Meteorological Organization Global Ozone Research and Monitoring Project-Report No. 18, 1990 is in the process of being printed. The U.N. Environmental Program (UNEP) review and assessment has been held and the report completed. Preparations will begin for the next evaluation. The committees to be formed have not yet been identified.

W91-70312 **464-50-00**
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 process 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.

W91-70313 **464-51-03**
Goddard Space Flight Center, Greenbelt, MD.
TROPOSPHERIC PHOTOCHEMICAL MODELING
Anne M. Thompson 301-286-2629

The objectives of this RTOP are (1) analyze field data (from tropospheric missions including NASA/GTE/ABLE) to derive ozone budgets in troposphere; (2) predict perturbations to tropospheric CH4-CO-NO(x) and O3-OH with a photochemical model (assessment calculations); and (3) perform uncertainty analysis of computed trace gas concentrations and implications for O3 budget and assessment calculations. The approach is to combine modeling and data analysis to derive ozone and other photochemical budgets from detailed study of individual events from field experiments. Modeling uses 1-D model in coordination with Code 612 cloud model. The 1-D model is used for multiple runs based on alternative scenarios and various chemical environments to evaluate perturbations and uncertainties in ozone and OH.

Solid Earth Processes

W91-70314 **465-10-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS OF BUOYANT VOLCANIC PLUMES
S. M. Baloga 818-354-2039

There are three major goals for this research: (1) to demonstrate the feasibility of simultaneous visible, UV, and IR measurements for improving the understanding of the dynamics of buoyant plumes; (2) to establish the limits of validity of enhanced Morton-type models for buoyant plumes; and (3) to develop the theoretical and measurement methodology basis needed by large scale volcanological studies related to Earth Observing System (EOS) or other remote sensing studies. The first element to the approach is to collect simultaneous ground based visual, UV, and IR images of progressively larger buoyant plumes. We will begin by measuring a relatively small industrially generated steam plume, then progress to a large scale industrial plume (Portsmouth Gaseous Diffusion Plant, Piketon, OH) that contains small quantities of solids and condensing water droplets, and finally a large scale, high temperature fumarole at Hawaii. Data on the dimensions, variability, and statistical fluctuations will be compared with the results of a theoretical model for the mean velocity, radius, and density of a buoyant plume with (solid or liquid) condensates, latent heat release, and thermal radiation. This approach will establish the limits of validity of Morton-type models that have been used frequently in the volcanology literature. The theoretical model will be extended on the basis of the data/theory comparison to embrace large scale volcanic eruptions, for which atmospheric conditions are more important. Toward the conclusion of this research, we will assess the implications of this new knowledge as it applies to the dynamics of rising buoyant plumes for related remote sensing studies.

W91-70315 **465-10-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LUNAR LASER RANGING SYSTEMS AND INSTRUMENTATION
M. S. Scholl 818-354-2313

The objective of this program is to perform system engineering and to implement the requisite technology upgrades for the lunar laser ranging stations to increase the quantity and the quality of data acquired at the stations. There have been corner reflectors on the Moon since the Apollo program. A number of organizations have been using them to collect data for geodynamics, atmospheric, and gravitational analysis. The experience of the French has shown that a ten-fold increase in the number of usable data over that collected in Maui is possible with the system approach to Lunar laser ranging instrumentation. Additionally, alternate techniques will be investigated to expand the operation of the laser ranging stations to those times during which, for spurious reasons, it has not been possible to take data in the past, such as when reflectors are not illuminated by sunlight, or when the atmospheric conditions are not optimal. During FY-91, this investigation will concentrate on the Haleakala Station on Maui and the McDonald Station in Texas, to evaluate the environmental, engineering, and physical conditions which determine the frequency and quality of the data being attained. This will be performed in close collaboration with resident staff during on-site visits. Also, evaluations will be performed at other laser ranging stations during their observations to assess how different environmental, physical and operational conditions affect the signal-to-noise ratio of the return signal there. Detailed analysis of the stations will include the signal-to-noise considerations, timing effects, and recommended calibration procedure. Those subsystems, components or environmental conditions which most directly impact the frequency and quality of data will be identified. Alternate technologies will be assessed as to their ability to contribute to efficient operation of the instrumentation at the laser ranging stations.

W91-70316 **465-10-00**
Goddard Space Flight Center, Greenbelt, MD.
GEODYNAMICAL MODELING TECHNIQUE DEVELOPMENT
Maria T. Zuber 301-286-2129

The objective of this study is to develop mathematical and computational techniques to apply to a range of theoretical geodynamical and geophysical modeling problems. This will be accomplished by designing a series of efficient, and whenever possible, general, numerical algorithms. Emphasis in the coming year will include development of a complex finite element program to model geodynamic stress and strain fields, a tensor solver/symbolic manipulator to yield nonlinear solutions of the gravitational field equations, and a nonlinear differential equation solver to model chaotic processes in geodynamics.

W91-70317 **465-12-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TECTONIC EVOLUTION OF LARGE OFFSET TRANSFORM FAULTS DURING CHANGES IN RELATIVE PLATE MOTION
C. A. Raymond 818-354-8690

The proposed research will investigate the tectonic evolution of several large offset transform faults during changes in relative plate motion. We seek to explain the occurrence of anomalous ridge and trough topography and other anomalous features such as oceanic plateaus present at such zones in the context of the residual stress field during plate motion reorganizations. These departures from normal oceanic crustal depth, termed depth anomalies, are widespread in the worlds' oceans, but few satisfactory explanations have been offered to explain them. The tectonic evolution of several oceanic transforms will be studied by analyzing data from the Seasat and Geosat satellite altimeter missions, in conjunction with shipboard observations of topography, gravity and magnetic anomalies. The data will be analyzed in the context of existing models to account for ridge and trough topography in fracture zones, and a model of stresses at large offset transforms that occur when the local transform azimuth deviates from the relative motion vector.

W91-70318 **465-12-00**

Goddard Space Flight Center, Greenbelt, MD.

SOLID EARTH DYNAMICS

Steven C. Cohen 301-286-8826

The objective of this RTOP is to conduct research and provide support for research relating to the solid earth, its dynamics, structure and interior composition. The approach is to (1) determine the large-scale structure and magnetization contrast between the continental and oceanic lithosphere; (2) study the correlation between earthquakes and polar motion; (3) perform long-term solar system integration studies; (4) provide administrative management for grants and contracts and conduct studies of satellite altimetry over inland seas; (5) prepare and exercise the geodynamics management data base; (6) develop finite element models of plate boundary deformations; (7) support geodynamic applications of the Geoscience Laser Ranging System; (8) study lithospheric structure and dynamics based on gravity-topography correlations and modeling; (9) develop models of subduction zone tectonics; and (10) study Earth rheology and spin axis obliquity.

W91-70319 **465-20-00**

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

PLATE MOTIONS OVER THE PAST 700,000 YEARS: IMPLICATIONS FOR SPACE GEODETIC MEASUREMENTS AND EXPERIMENTS

D. C. DeMets 818-354-7720

In order to span the wide gap between yearly plate velocities measured from geodetic data and the 3.0 Ma (million year) average velocities given by models for present day global plate motions, globally distributed, high quality marine magnetic and bathymetric data will be analyzed to determine 0.7 Ma and 1.7 Ma plate velocities. Many data indicate that plate motions have changed measurably since 3.0 Ma; thus, it is unclear whether to expect close agreement between geodetically determined velocities and 3.0 Ma-average velocities. Knowledge of global plate velocities spanning 4 intervals over the past 3.0 Ma will, for the first time, give reliable information about the time variability of plate motions on million year time scales, and it will permit an assessment of the agreements and disagreements between geologically determined plate velocities and those measured from satellite laser ranging, very long baseline interferometry, and Global Positioning System techniques. Additionally, several smaller plates that are presently excluded from rigid plate models will be incorporated into this analysis. This work should benefit several ongoing or recently proposed GPS projects, and facilitate future interpretations of geodetic measurements. The proposed analysis entails detailed modeling of existing marine magnetic data, construction of quantitative models for post-3.0 Ma plate velocities, and comparison of geodetic measurements to instantaneous velocities extrapolated from the geological models derived here. The output will be useful for a wide variety of geoscientific and geodetic research.

W91-70320 **465-20-00**

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

GPS GLOBAL NETWORK FOR TRACKING AND SCIENTIFIC APPLICATIONS

R. E. Neilan 818-354-8330

The Global Positioning System (GPS) Global Network RTOP will coordinate, implement and operate a highly reliable, precise, international GPS tracking system for the 1990's required for solid earth dynamics programs and Earth remote sensing missions. This system will: establish a sound GPS tracking infrastructure, transparent to general users, and will support required accuracies of up to 1 x 10(exp 9) with tracking and data products; demonstrate continuous reliability and internal consistency; produce accurate GPS ephemerides and ancillary data products; participate in maintaining the precise terrestrial reference frame; and provide for collection, processing, interim archiving, accessing, monitoring and assessing of system data and status. The total system also will provide the very accurate GPS orbit determination and terrestrial reference frame control required for a number of NASA sponsored ground and space-based missions such as regional geodynamics campaigns, TOPEX/Poseidon, Earth Observing System, Space Station Freedom, Gravity Probe B, Spinsat, Aristoteles, and Columbus. The implementation of this system will establish the GPS core of FLINN (Fiducial Laboratory for an International Natural Science Network), as well as establish configuration standards for global GPS station densification through the next decade. The system derives synergistic benefits from the GPS global tracking activity already sponsored by NASA (Codes T and EED) in support of TOPEX and by activities of other organizations such as CIGNET (Coordinated International GPS Network). A major objective of this RTOP is to consolidate these related networks and expand into a highly organized, integrated and consistent global network that will provide a broad class of scientific users with very accurate GPS tracking data and products. This RTOP was a task under GPS Based Measurement System Development RTOP in FY-89 and FY-90. Under this task, intra-NASA coordination (Code T and E) resulted in data links and assured access to the 6 station network being implemented in support of TOPEX/Poseidon, thus enabling access to the quality GPS tracking data currently being collected at NASA's 3 Deep Space Network stations by the Geodynamics community. from the three additional stations as they become operational. However, a substantial core network to support a global geodynamics program (leading to FLINN) ultimately requires an additional 10 to 15 stations worldwide. Realization of the expanded network depends on a strong NASA/SES role for continued inter-Agency and international coordination. In order to achieve the objectives, the RTOP will focus on three closely linked tasks: the scientific and technical rationale and recommendations; system implementation, operation and coordination; and establishment of distributed data information and analysis capabilities with links to the Crustal Dynamics Data Information System (CDDIS).

W91-70321 **465-20-00**

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

MEASUREMENTS OF PRESENT DAY CRUSTAL MOVEMENTS IN THE INDIA-EURASIA COLLISION ZONE

G. Peltzer 818-354-7539

The goal of the proposed research is to use the Global Positioning System and satellite imagery to constrain the present day crustal deformation in the India-Eurasia collision zone. The specific objectives are: (1) To determine the way deformation is distributed within the Asian continent (localized into major fault zones such as the Altyn Tagh, Kunlun or Red River faults, or continuously distributed across the continent); (2) To estimate the amount of crustal shortening absorbed in the Himalayas, distributed across Tibet and in the Kunlun mountains, along the north edge of the Tibetan plateau (Altyn Tagh, Qilian Shan), and north of the plateau, in the Tien Shan and the Altai; (3) To estimate the magnitude and variation along strike of strike-slip motion taking place on major faults in SE Asia (e.g., Altyn Tagh, Kunlun, Karakorum, Xianshuihe, Qinling, and Red River faults) as well as the rotation rates of continental blocks bounded by such faults; and (4) To use results from (2) and (3) to establish a mass balance budget over the entire collision zone in order to estimate the respective fractions of the north-south shortening between India and Asia which are absorbed by crustal thickening and lateral extrusion of continental blocks. A tentative GPS geodetic network has been designed to meet the above objectives. A covariance study performed at JPL has demonstrated the feasibility of such an experiment using the GPS. After two measurement campaigns, estimates of baseline length variations will be used to constrain kinematic models of continental deformation in the India-Eurasia collision zone. Analysis of an extensive set of satellite images (SPOT and LANDSAT TM) covering tectonically active regions of China, and concurrent field studies will allow us to compare present day deformation rates inferred from the GPS measurements with longer term rates inferred from the geological and morphological record.

W91-70322 **465-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEODETIC MEASUREMENTS IN THE SOLOMON ISLANDS REGION USING THE GLOBAL POSITIONING SYSTEM
P. R. Lundgren 818-354-1795

The objective of this RTOP is to measure present-day rates of plate motion and crustal deformation in the Solomon Islands region, which is characterized by high plate velocities and complex, rapidly evolving plate boundaries which are important analogues to present and past plate tectonic processes. Some parameters to be measured are: (1) Spreading rates across the Bismarck back-arc basin and the Woodlark Rift; (2) Subduction rates across the Solomon-Bismarck, Solomon-Pacific, and Australia-Pacific, plate boundaries; (3) The deformational effects of subducting the Woodlark Rift at 12 cm/yr beneath the northwestern Solomon Islands; (4) Determine if convergence is occurring at the Manus and North Solomon Trenches; (5) The motion across the proposed Micronesian Trench; and (6) Shear deformation effects in the Solomon Islands due to oblique Pacific-Australia convergence. The approach will be to: (1) Establish a 17 station geodetic network in the Solomon Islands and adjacent islands in the SW Pacific; (2) Perform 2 Global Positioning System (GPS) measurement campaigns two years apart; and (3) Analyze and interpret the GPS results.

W91-70323 **465-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A GPS INVESTIGATION OF OBLIQUE SUBDUCTION AND ASSOCIATED DEFORMATION IN ALASKA
D. C. DeMets 818-354-7720

The Aleutian Island Arc, Alaska, has been identified as a textbook example of a forearc that is presently deforming from the force of oblique subduction. As the Pacific plate plunges beneath North America, the Aleutian Island forearc is being stretched out westward, fragmenting in the process. We seek funding to study this deformation using Global Postioning System (GPS) geodetic techniques. The Aleutian Island arc is well-suited for geodetic measurements because deformation is sufficiently rapid for detection with only a few years of GPS data. GPS data will provide essential kinematic information complementary to the detailed geologic, seismologic, paleomagnetic, and marine geophysical data that have contributed to our present understanding of the island arc. We expect to gain knowledge about the complexities of subduction that can be applied elsewhere in the world, and hope to gain insight into the processes and forces that produce the major earthquakes which frequently strike Alaska. Our principal observational goal is to measure the rotations and translations of the forearc blocks that comprise the island arc, with respect to fixed sites in Alaska and the Pacific. We plan to occupy approximately nine sites along the Aleutian arc and another seven sites elsewhere in Alaska during two campaigns spaced two years apart. Data from a number of global tracking sites will also be available. Baselines will be initially measured in the summer of 1991, with a subsequent occupation in the summer of 1993. Sub-centimeter precision is expected on these GPS baselines from the judicious use of JPL-developed high precision Rogue receivers in combination with more numerous commercial receivers. A two year time span should be adequate to resolve the largest motions expected in the Aleutians, the westward translation of the end of the chain at up to 45 mm/yr, and to constrain the rotation rate of those blocks thought, from geological data, to be rotating most rapidly. Additional observational goals include the continued monitoring of the crustal Dynamics Project Very Long Base Interferometry (VLBI) sites in mainland Alaska and the establishing of epoch baseline measurements for a long term study of the deformation associated with great subduction earthquakes. We intend to collaborate closely with several university groups who have field expertise and overlapping research interests in the Aleutians. We will take full advantage of JPL's state-of-the-art expertise in GPS receiver technology and GPS data processing software to obtain the highest quality baseline measurements possible.

W91-70324 **465-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS POSITIONING OF A BUOY FOR SEAFLOOR GEODESY
L. E. Young 818-354-5018

The purpose of this RTOP is to develop a system to monitor plate boundary deformations, and relative plate motions, at typical underwater plate boundaries. The RTOP objectives are to perform the analysis, development, and demonstration of the GPS portion of a combined GPS/acoustic system for determining the location of an ocean surface platform with respect to the GPS reference frame. The development of a system for measuring the location of benchmarks on the ocean floor with respect to an acoustic transmitter on the surface platform is being performed under other Geodynamics Program sponsored research, by F. N. Spiess of Scripps Institution of Oceanography. The combined objective of these two RTOPs is to precisely tie ocean floor benchmarks to an earth fixed reference frame. GPS-based systems have been developed for high precision, cost effective geodetic measurements under the NASA Geodynamics Program. Current receivers have demonstrated baseline measurements on land with sub cm accuracies. The measurement of baselines to an acoustic transducer, suspended below a buoy, is a more difficult problem. The platform kinematics place strict requirements on the accuracy of GPS range measurements, and the translation of position information to a sub-surface point requires the determination of platform attitude. Rogue GPS receivers, with high accuracy range measurements, will be used in this system. A short baseline interferometer, with three antennas will be used on the buoy to solve for attitude. This system is expected to give accuracies of a few cm in the location of the sub-surface acoustic transducer relative to a GPS reference on land, or relative to another seafloor geodesy system.

W91-70325 **465-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN INVESTIGATION OF THE KINEMATICS OF CONTINENT-ISLAND ARC COLLISION IN PAPUA NEW GUINEA USING GPS: SPATIAL AND TEMPORAL VARIATIONS
Kenneth J. Hurst 818-354-6637

We propose to use the Global Positioning System (GPS) in Papua New Guinea to investigate the kinematics of a collision between the Australian continent and an island arc, and to test for constant velocity of the South Bismark plate. The rapid plate velocities and non-parallel geometry between the continent and island arc combine to yield a situation uniquely suited to study using GPS. The rapid plate velocities imply a high signal-to-noise ratio over time spans as short as 2 years. The oblique geometry implies that the locations of the collision has migrated to the east over the past 5 Ma, allowing us to examine the deformation at different stages before, during, and after the collision. The existence of two prior crustal motion networks will allow us to draw tectonically meaningful conclusions after the first epoch of GPS measurements unlike most crustal dynamics GPS surveys which must wait for the second epoch. The existence of the Doppler crustal motion network surveyed in 1981 will also allow us to assess the uniformity of the motion of the South Bismark plate relative to the Australian continent after the second epoch of GPS measurements. The South Bismark plate has no subducting slab. Slab pull has been suggested as the major force in driving the plates. The presence or absence of variations in the motion of the South Bismark plate as a whole should place constraints on the other plate driving forces (ridge, push, transform coupling, basal drag, and collisional forces).

465-20-00

W91-70326

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

STUDY OF OBLIQUE PLATE CONVERGENCE IN SUMATRA

Y. Bock 818-354-1835

The objective of this RTOP is to provide support for resurveying with Global Positioning System (GPS) additional stations of the 19th century Dutch triangulation in Sumatra, and to provide support for performing a strain analysis of the triangulation data and GPS measurements. These data will be invaluable in understanding the mechanism of how oblique plate convergence between the Indian-Australian and Eurasian plates at the Java trench decouples into normal and strike-slip components, the latter presumably along the Sumatra fault which is spanned along its entire 1500 km length by the Dutch triangulation network.

465-20-00

W91-70327

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

GLOBAL POSITIONING SYSTEM GEODETIC MONITORING OF SOUTH AMERICAN-NAZCA PLATE CONVERGENCE

T. H. Dixon 818-354-4977

The boundary between the oceanic Nazca Plate and the continental South America Plate provides an excellent setting in which to study several crucial aspects of the convergence process. Convergence is distributed between the subduction interface at the Peru-Chile trench (where great earthquakes occur) and the Andean Cordillera (the zone of volcanism, uplift and thrusting between the trench and stable South America). The kinematics and mechanics of such regions where the geometry of subduction varies dramatically are poorly understood. Convergence rates estimated from global plate motion models disagree with seismic slip rates at the trench, and both of these estimates disagree with a single satellite laser ranging baseline. These issues will be addressed with the South America-Nazca Plate Project (SNAPP) using the Global Positioning System to acquire geodetic measurements across the Peru-Chile Trench. A series of geodetic baselines from the South American mainland to the Juan Fernandez and San Felix Islands, 800 to 1000 kilometers offshore, will allow definition of the spatial variation in convergence along a few thousand km of the trench. These baselines, combined with a series of baselines crossing the Andes and the Altiplano-Puna plateaus, will define distribution of plate boundary motion between the interior of the Nazca plate and stable South America.

465-20-00

W91-70328

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

HAYWARD FAULT SURVEILLANCE PROJECT: REAL-TIME ON-LINE SEISMIC AND GPS DIAGNOSTIC MONITORING SYSTEM

D. M. Tralli 818-354-1835

The combined use of long-period seismic instrumentation and high-precision Global Positioning System (GPS) geodetic measurements is proposed to monitor strain changes on the Hayward fault, California, associated with creep and potential large-scale fault failure. Near-field strain measurements, geodetic data, and low-frequency seismic data are required to detect deformation events in the low region of the characteristic rupture velocity spectrum. The spatial and temporal relationships between slow deformation and ordinary ruptures are not clear. Studies of low-frequency seismic events address questions on earthquake nucleation, and fall within the scope of earthquake prediction. Incorporating a GPS monitoring network into an array of long-period and digital broadband seismometers offers an opportunity to observe portions of the deformation with data of overlapping low-frequency response, with the high-frequency response constrained by near-field downhole seismometers to image the onset of failure. NASA support is requested for a fixed GPS monitoring network as an element of a comprehensive fault surveillance effort, which includes seismic instrumentation supported by the U.S. Geological Survey and State of California (in addition to support for geodetic monitoring). The GPS network would be established at a level of 4 permanent sites per year for two years, expanding to a target goal of 15 fixed sites in 3 years. The GPS data from the monitoring site will be telemetered to a central facility of the Berkeley Seismographic Stations and Lawrence Berkeley Laboratory, in conjunction with seismographic data (which is already carried out routinely). The Jet Propulsion Laboratory will help set up the geodetic monitoring network, establish the on-line real-time GPS data processing capabilities, and collaborate on the interpretation of results.

465-21-20

W91-70329

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. Potential improvements will be investigated 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 acquisition and tracking software and computer algorithms for unmanned operations.

465-23-00

W91-70330

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

STRAIN ACCUMULATION MONITORING IN THE NEW MADRID SEISMIC ZONE USING THE GLOBAL POSITIONING SYSTEM

D. M. Tralli 818-354-1835

Large earthquakes in the New Madrid seismic zone (Missouri, Arkansas, Illinois, Kentucky, Tennessee) such as the great 1811-12 earthquakes, pose a serious hazard to the central U.S. The magnitude, moments, and fault geometry of these events have been inferred using isoseismal data. However, the locations and mechanisms of more recent earthquakes have been used to delineate the seismic zone and to analyze the faulting in the larger post-1960 events. Earthquake recurrence and probability estimates have been derived from historic magnitude-recurrence data. The absence of recent large earthquakes poses difficulties: mechanisms are available only for events with mb less than or equal to 5.0, and the recurrence estimates for events with mb less than or equal to 6.4 require significant extrapolations. The seismic zone overlies the Reelfoot rift, a Precambrian to Early Cambrian rift system buried by thick Phanerozoic strata and Quaternary alluvium. Recent seismicity appears related to reactivation of fossil rift-related faults by the current stress field. We propose to initiate a collaborative research program using Global Positioning System (GPS) geodesy to quantify the rate and distribution of strain accumulation in the New Madrid seismic zone. We will establish and measure a series of geodetic baselines between approximately 25 sites within the New Madrid seismic zone and at more regional distances, with the long-range goal of using annual measurements to determine baseline changes and thus provide quantitative constraints on the regional tectonics, fault zone mechanics, and earthquake recurrence.

465-32-00

W91-70331

Goddard Space Flight Center, Greenbelt, MD.

SOURCES OF MAGNETIC ANOMALY FIELD

Patrick T. Taylor 301-286-5412

The objectives of this RTOP are to determine the geologic and tectonic nature of the long-wavelength crustal magnetic anomaly field recorded by MAGSAT; and to improve the methods and techniques for reducing and interpreting these anomalies and those obtained by future missions (e.g., Tether (1994) and Aristoteles). The MAGSAT crustal field and several regions selected for detailed study based on their geologic/tectonic significance and magnetic field characteristics. Techniques and programs, previously developed, have enabled rapid progress to be made in these studies. These programs and methods must be continually upgraded in order to utilize the new computer hardware advances being made at GSFC (i.e., new CRAY and MPP machines). The interpretations of these anomalies are based on computer models whose parameters are derived from geologic studies and magnetic property analysis made on rocks which simulate the conditions found in the lower crust and upper mantle. Estimates can be made about the nature of the magnetization producing the anomalies (i.e., TRM, VRM versus induced). This RTOP represents an integrated approach to the study of MAGSAT data. Gravity anomaly data, results from seismic refraction and tele-seismic studies, and LANDSAT images were utilized.

W91-70332
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 465-35-00
ARISTOTELES GEOPOTENTIAL FIELD RECOVERY
T. P. Yunck 818-354-3369
(677-80-19; 676-59-31)

Through computer modeling and analysis of existing data from satellite and airborne instruments, geophysical studies will be conducted to refine the science objectives of the mission and to formulate hypotheses to be tested with the gravity and magnetic data returned by Aristoteles. A systematic effort will be made to identify suitable data for this activity. Possible sources include Topex/Poseidon, the space shuttle, and airborne experiments. System design tradeoff studies will be conducted to maximize the science return with a complementary and cost-effective suite of instruments. The studies will employ modeling of instrument operation and performance, simulation of data products and processing, and covariance studies, for both flight and ground systems, including science, tracking, and attitude instruments. Optimal filtering techniques will be devised to extract the highest quality field measurements through simultaneous reduction of mutually dependent data from all sensors. An annual report will be prepared presenting the results of these activities. Presentations and technical papers will also result from this work.

W91-70333
Goddard Space Flight Center, Greenbelt, MD. 465-35-01
MISSION STUDIES (MFE/MAGNOLIA AND ARISTOTELES)
G. W. Ousley, Sr. 301-286-8073

The objective of this RTOP is to conduct system definition studies for a Magnolia Magnetic Field Explorer (MFE) mission, studies for adapting Magsat designs to Aristoteles, and studies on Lageos-3 as agreed. The studies will be based on the Magsat-A concept and will build on the studies completed by APL.

W91-70334
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 465-40-00
INFLUENCE OF POLAR MOTION ON EARTHQUAKES
R. S. Gross 818-354-4010

The fundamental objective of this study is to address the question of whether the Earth's polar motion has any influence on the occurrence, particularly the timing, of earthquakes. Since this influence, if it exists, is expected to be rather small at best, its detection is possible only through statistical tests utilizing large sample data sets. An earthquake catalog consisting of some 8000 earthquakes of magnitude greater than 5 that have occurred in the past 13 years will be used in these statistical tests. Two approaches based upon different physical considerations will be followed. Both entail studying the statistical distribution of the angular difference between certain angular parameters of the earthquake and the longitude lambda sub m of the pole position at the time of the earthquake. The statistical distribution of delta lambda sub 1 is equivalent to lambda sub e minus lambda sub m, where lambda sub e is the longitude of the earthquake epicenter. If earthquakes are completely indifferent to the location of the Earth's rotation pole, then delta lambda sub 1 should have a statistically uniform distribution in the range (0 deg, 360 deg). If, on the other hand, the polar motion can influence the occurrence, particularly the timing, of earthquakes through the stress field it induces in the Earth (which depends on cos delta lambda sub 1), then this influence may manifest itself as a (slight) departure of delta lambda sub 1 from a uniform distribution. By studying the distribution of delta lambda sub 1 the existence of such an influence can be detected. The statistical distribution of delta lambda sub 2 is equivalent to lambda sub psi minus lambda sub m where lambda sub psi is the longitude of the polar motion excitation caused by the earthquake. The polar motion energy change due to an earthquake depends upon cos delta lambda sub 2 (in the form of the vector dot product of the polar motion m with the polar motion excitation, psi). In a previous study it was found that earthquakes have a strong tendency to decrease the Earth's gravitational energy while increasing the spin energy. Thus, studying the statistical distribution of delta lambda sub 2 is interesting with respect to the corresponding tendency in the polar motion energy change. More importantly, though, any non-randomness in this distribution signifies possible influences of the polar motion on the time of occurrence of earthquakes.

W91-70335
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 465-40-00
COSEISMIC EFFECT OF EARTHQUAKES
R. S. Gross 818-354-4010

The fundamental objective of this study is to examine the individual and cumulative coseismic effects of earthquakes on global geodetic properties of the Earth. We will study both the long-term (century) and short-term (decade) changes that occur in these properties, as well as their interrelationships. Our approach will be to first compute the earthquake-induced deformation field of the spherically symmetric, non-rotating, elastic, isotropic (SNREI) Earth model 1066B by expanding the deformation field as a weighted sum of the normal mode eigenfunctions of 1066B. For this calculation we will use two different earthquake source mechanism data sets: (1) the centroid-moment tensor solutions being routinely determined and published by the Harvard Group for all earthquakes having seismic moment M sub o greater than 10 to the 24th power dyne-cm (solutions for more than 7500 earthquakes that have occurred since 1977 are currently available); and (2) the source properties for the greatest (M sub o greater than 10 to the 24th power dyne-cm) earthquakes to have occurred since 1900 that have been determined and published in the publicly available literature. We will then determine the effect that these earthquakes have had on the secular drift of the Earth's rotation pole, the polar motion, and the Earth's shape as measured by changes in baseline lengths and orientations.

W91-70336
Goddard Space Flight Center, Greenbelt, MD. 465-40-00
STRUCTURAL AND GEOBOTANICAL EXAMINATION OF THE QUETICO FAULT SYSTEM AND QUETICO PROVINCIAL PARK USING X AND C BAND RADAR
Robin Bell 301-286-3621

The primary objective is to investigate the utility of radar data for geologic interpretation in a heavily forested region of the Canadian Superior Province. We propose to incorporate radar data into a regional geological, geobotanical and structural mapping investigation in the Superior Province of NW Ontario. One goal is to examine whether surface fracture patterns along a fault can be related to degree of post-faulting uplift. Another is to investigate the backscatter characteristics of different geobotanical classes and to integrate radar with visible and infrared to improve geobotanical lithologic mapping capabilities. First, photointerpretation of enhanced radar data will be undertaken to define the surface fracture patterns along a major fault system and to evaluate a geomorphic approach to radar geology of forested areas (the latter using stereo). Second, computer manipulation and integration with visible and infrared data and statistical analyses will be undertaken for comparison of radar bands for lithologic/structural and vegetation mapping.

W91-70337
Goddard Space Flight Center, Greenbelt, MD. 465-40-00
REMOTE SENSING GEOBOTANICAL/LITHOLOGIC MAPPING IN THE CANADIAN SUPERIOR PROVINCE BOREAL AND BOREAL TRANSITION FOREST OF NW ONTARIO
Robin Bell 301-286-3621

The primary objective is to investigate the rock-soil-plant relationships within the Superior Province southern boreal forest of NW Ontario for purposes of lithologic mapping using remote sensing. Emphasis is on anomaly detection based upon the spectral reflectance of boreal tree species patterns for mapping of ultramafic and/or areas of potential economic interest. Remote sensing data will be processed to maximize information on conifer/deciduous tree species assemblage reflectance patterns. Specific reflectance patterns previously found associated with soil/rock geochemical anomalies, e.g., ultramafic localities, will be identified and compared with available information in map form on geology and soil. Multitemporal thematic mapper (TM) datasets will be used. Aerial photography will be used to supplement the map base where needed.

W91-70338 465-42-05
Goddard Space Flight Center, Greenbelt, MD.
COASTAL PROCESSING
James R. Heirtzler 301-286-5213

There are two RTOP objectives: to use remote sensing imagery to determine shoreline changes with time for the most vulnerable coasts; and to establish quantitative relationships between these changes and other environmental changes. Continuing the work of a previous RTOP, the approach will be to acquire Advanced Very High Resolution Radiometer (AVHRR), Multispectral Scanner (MSS), Thematic Mapper (TM), and Speed POsition and Track (SPOT) data, as appropriate and as funds permit, for the 18 years that remote sensing data has been available. Two images, with different times of acquisition, will be co-registered and then differenced to document changes. Where possible, ground truth will be obtained to substantiate these findings and to use in modeling these changes with atmospheric, oceanographic, or tectonic parameters. Work with oceanographic institutions and scientists in the country involved will be continued. Work will be divided into two tasks: complete work on the Nile Delta, especially the part of the delta associated with the Dametta branch of the Nile; and begin to study the coast of Bangladesh, which is comprised mostly of the Bengal Delta.

W91-70339 465-42-05
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, using remote sensing imagery and other satellite data supplemented by other geophysical and geological databases. The initial RTOP on this subject has permitted acquisition of most of the existing remote sensing data and significant other digital databases for the East African Rift and to make some initial interpretations. Existing Thematic Mapper (TM) and Multispectral Scanner (MSS) imagery has permitted an analysis of the Dead Sea Transform Fault system, a comparison of geology across the northern Red Sea, tectonic features of the Afar region and a study of how vegetation is related to topography, so it will not be confused with tectonic features. New data have permitted an analysis of the structure of several of the major volcanic centers, a comparison of remote sensing imagery to geologic maps of several East African countries, and new Advanced Very High Resolution Radiometer (AVHRR) LAC data has permitted the undertaking of a single mosaic of the entire East African Rift system. This mosaic will serve as a standard for the undertaking of a uniform analysis of the Rift system as a whole. Five by five degree blocks of this data along the Rift will be studied to identify, for the first time, all tectonic and volcanic features and to determine the relationships between them.

W91-70340 465-44-03
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 regions of SW Iceland. This RTOP 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 lava on Surtsey will be investigated.

W91-70341 465-44-11
Goddard Space Flight Center, Greenbelt, MD.
VOLCANIC STUDIES
Louis S. Walter 301-286-2538

The goals of this RTOP are to expand the understanding (1) of volcanic processes, (2) the effect of explosive eruptions on regional and global climate and, (3) the geochemistry of volcanic sulfur. The objectives are to quantitatively determine volcanic SO2 emissions and dissipation, assess the effect of volcanic SO2 on climate parameters, and, define requirements for future sensors and missions for SO2 measurements. The approach is 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; correlate SO2 emissions with climate parameters; 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.

W91-70342 465-60-00
Goddard Space Flight Center, Greenbelt, MD.
GEOLOGICAL STUDIES OF THE CANADIAN SHIELD WITH ERS-1 AND AIRBORNE IMAGING RADAR
Paul D. Lowman 301-286-7520

Several major tectonic problems with global implications have been under investigation as part of a Shuttle Imaging Radar (SIR-B) experiment: the nature of the Grenville and Nelson Fronts (supposed sutures), the origin of regional fracture systems, and the origin of major dike swarms. The SIR-B experiment was completed, but served as the foundation for a Canadian-American ESA Remote Sensing Satellite-1 (ERS-1) proposal, accepted by ESA. Its objectives are similar to those of the SIR-B experiment, with the addition of an investigation of the origin of the Sudbury Basin by determination of its original shape and size. Imaging radar data from ERS-1, expected early in CY 1991, will be studied to assess its value and the best methods for using it. Various enhancement techniques developed in the course of the SIR-B experiment will be tested, and new techniques tried. Since ERS-1, unlike Shuttle missions, will be a long-term satellite, this work will continue for several years. During the evaluation phase, ongoing geologic studies will continue, using simulated orbital radar acquired by the Canada Center for Remote Sensing. Field work will be carried out as possible, and data and results will continue to be exchanged with Canadian colleagues on the ERS-1 team. Radar data from Magellan will be compared with ERS-1 data when it becomes available. Results of the ERS-1 investigation will be utilized, as were those of the SIR-B study, in a long-term study of the origin of continental crust.

W91-70343 465-67-02
Goddard Space Flight Center, Greenbelt, MD.
LASER ALTIMETER TECHNOLOGY
J. L. Bufton 301-286-8740
(677-43-24; 677-43-28; 161-10-03)

The objectives of this RTOP are to: develop the technology and techniques of laser remote sensing of earth surface topography from aircraft and spacecraft platforms; and provide the laser altimeter instrument capability and operational support for airborne topographic science field missions to meet the science requirements and data acquisition objectives of the NASA Geology Program. Research and development activities involve the improvement of laser altimeter instruments and the use of laser altimeter instrumentation in airborne science investigations. Laser altimeter instrument components under development include state-of-the-art diode-pumped solid state laser technology, sub-nsec timing and digitization electronics, and microprocessor-based data acquisition and storage systems. Development and operational deployment of an airborne laser altimeter system is the prime method of introducing and evaluating new technology for its scientific merit. The airborne laser altimeter system is configured for operations on the NASA Wallops Flight Facility T-39 aircraft with a baseline capability of range profiling at nadir with sub-meter vertical resolution and meter level horizontal resolution for aircraft altitudes to 10 km. The airborne laser altimeter instrument is maintained in an operational state as a testbed for technology improvements and as a data acquisition platform for NASA Geology Program field missions. Approximately one major field mission per year is supported by this task.

W91-70344 **465-67-03**
Goddard Space Flight Center, Greenbelt, MD.
TOPOGRAPHIC PROFILE ANALYSIS
James B. Garvin 301-286-6565

This project will quantitatively analyze high-resolution topographic profiles obtained from aircraft laser altimetry, in order to explore and define fundamental wavelengths associated with dynamic surface processes such as volcanism and coastal erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a GSFC aircraft laser altimeter (1 to 10 m footprints, approximately .5 m vertical precision) and, will for the first time, permit exploration of the spectral topographic and (and slope) properties of coastal erosion and active volcanism. Data has or will be obtained from the GSFC aircraft laser altimeter (developed by J. Bufton of Code 674 and colleagues) for selected targets including youthful volcanics (CIMA flows, Death Valley) and coastal erosion features (Delmarva barrier islands and Nauset/Monomay at Cape Cod). High resolution (spatial and vertical) topographic profiles will subsequently be analyzed by means of classical spectral analysis and interpreted. Dominant wavelengths associated with specific terrains and processes will thus be defined; such data can then be used as boundary conditions in mechanical models for certain landforms. Major FY-90 activities included studies of Cape Cod Coastal erosion by means of establishing a database of transverse beach profiles, and the support of the GRSFE Project. Major FY-91 activities will include a geodetic laser survey of Mt. St. Helens and analysis of GRSFE data collected in FY-90.

W91-70345 **465-70-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PORTABLE INSTANT DISPLAY AND ANALYSIS SPECTROMETER (PIDAS)
M. T. Chahine 818-354-6817

The Portable Instant Display and Analysis Spectrometer (PIDAS) was developed largely with funds from the Wm. F. Keck Foundation. The funds were granted to Caltech Professor Arden Albee, who was the PIDAS Principal Investigator, and the work was done at the Jet Propulsion Laboratory (JPL). The intention of the Keck Foundation was to turn the completed instrument over to NASA and Caltech to support research in the earth sciences. Because the amount of funding from the Keck Foundation was not adequate to complete the instrument, Caltech assisted by funding the $300 K that was required to complete the instrument. This was done with the understanding that Caltech would be reimbursed for the $300 K which was viewed as a loan to JPL. JPL reimbursed Caltech the $300 K in FY-89 from the Equipment and Instrumentation Fund (EIF), through an agreement between Dr. M. T. Chahine of JPL and Dr. S. G. Tilford of NASA that the NASA Earth Science Division would reimburse the JPL EIF the full $300 K over three (3) years at $100 K per year. The purpose of the RTOP is to secure the NASA funding required to pay back the EIF loan. PIDAS is currently operational and is in regular use in support of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). Caltech has been reimbursed by the JPL EIF. Under this RTOP, the EIF will be reimbursed $300 K, at $100 K/year for FY-90, 91 and 92. (Receipt of FY-90 funding is assumed for the purpose of this submission). Support of PIDAS continuing operation, maintenance and calibration is covered separately under RTOP No. 677-80-25.

Climate and Hydrologic Systems Modeling and Data Analysis

W91-70346 **578-10-00**
Goddard Space Flight Center, Greenbelt, MD.
PARAMETERIZATION OF MESOSCALE HYDROLOGY OF SEMIVEGETATED LANDSCAPES USING SATELLITE MULTISPECTRAL IMAGERY
M. F. Jasinski 301-286-7099

The objectives of this RTOP are to derive and test analytical parameterizations that characterize the subpixel (or subgrid) effect of spatially heterogeneous vegetation cover on mesoscale land surface reflectance and hydrology models, using a physically-based approach; to develop an inversion technique that estimates the two-dimensional distribution of subpixel fractional vegetation cover of semivegetated landscapes using the above models and satellite data without ground-truth; and to estimate hydrologic fluxes for selected semivegetated watersheds using a physically-based hydrologic model that incorporates the above parameterizations. Using a physical conceptualization of the landscape together with probability theory, parameterizations of subpixel vegetation cover and other subpixel properties (i.e., surface albedo, ground shadow) will be derived for common stochastic and deterministic plant spatial distributions that occur in natural and agricultural landscapes. The analytical models will be tested using computer simulations and aerial multispectral imagery with ground truth for selected semivegetated regions. The parameterizations will be incorporated into a physically-based inversion technique that estimates the two-dimensional spatial distribution of vegetation cover (i.e., on a pixel-by-pixel basis) using satellite multispectral imagery without ground-truth. The inversion technique will be based on an improved version of a stochastic-geometric land surface reflectance model previously developed by the author (Jasinski, 1989; Jasinski and Eagleson, 1990). The algorithm will be tested on three natural and one agricultural watershed using LANDSAT Thematic Mapper and NOAA Advanced Very High Resolution Radiometer (AVHRR) imagery. The subpixel parameterizations developed above will also be incorporated into existing land surface hydrology models. Daily, seasonal, and annual hydrological fluxes will be estimated for the above watersheds using the fractional vegetation cover distributions obtained above and available hydrometeorologic data.

W91-70347 **578-11-02**
Goddard Inst. for Space Studies, New York, NY.
EXTENSION AND TESTING OF THE HYDROLOGIC PARAMETERIZATION IN THE GISS ATMOSPHERE 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. The approach is to develop a global one-dimensional analog of the GISS general circulation model (GCM) that captures the essential radiative and convective processes of a global climate; compare various aspects of proposed GCM ground hydrology improvements in the one-dimensional model; and implement a new ground hydrology model in the GCM based on the results of the 1-D screening tests.

W91-70348 **578-12-01**
Goddard Inst. for Space Studies, New York, NY.
EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES
William Rossow 212-678-5567

The objectives of this RTOP are to: develop new multi-channel, multi-instrument cloud analysis algorithms, including new cloud detection schemes and more sophisticated radiative transfer models; and develop analysis methods to infer cloud-radiative feedbacks from the International Satellite Cloud Climatology Project (ISCCP) data. The approach is to examine ISCCP results by comparison to observations from full complement of instruments on the NOAA polar orbiters, including IR and microwave sounders; test new multi-spectral algorithms and radiative analysis models by comparisons to First ISCCP Regional Experiment (FIRE) observations of cirrus and marine stratus clouds; develop methodologies to infer cloud-radiative feedbacks from ISCCP data; compare results to products produced by Earth Radiation Budget Experiment (ERBE) and the Surface Radiation Budget Project; and also compare cloud and radiation budgets to climate model simulations.

W91-70349 **578-12-03**
Goddard Space Flight Center, Greenbelt, MD.
CLOUD AND RADIATION MODELING
Albert Arking 301-286-7208

The objectives of this RTOP are to: study atmospheric radiative processes and their effect on cloud thermodynamics and on surface energy budget; and validate representation of hydrological cycle in general circulation models (GCM's). The approach is to develop improved radiation models and participate in Intercomparison of Radiation Code in Climate Models (ICRCCM) intercomparison; study cloud/radiation/dynamics interactions using observations and theoretical models; and utilize GCM to determine global response to input data based upon satellite observations, including use of satellite and ground-based cloud climatologies.

W91-70350 **578-12-06**
Goddard Space Flight Center, Greenbelt, MD.
INTERACTIVE IMAGE DATA ANALYSIS
Franco Einaudi 301-286-6786

The objectives of this RTOP are (1) develop an interactive image spreadsheet which can be used to analyze multichannel satellite images over an image workstation; (2) maintain and expand the GEMPAK (General Meteorological Package) software and associated graphics software; and (3) transfer GEMPAK to NOAA NMC Development and Operations Division Unix workstations and use combined systems for joint GSFC/NMC research activity. The approaches are to (1) obtain Super Image Workstation and software, design and implement interactive image spreadsheet prototypes; (2) maintain GEMPAK software and documentation, extend the analysis functions, upgrade diagnostic package, and improve real-time data ingest; and (3) access data from NMC data base at GSFC and NMC, expand GEMPAK to add functions for post-processing model data.

W91-70351 **578-12-11**
Goddard Space Flight Center, Greenbelt, MD.
GMS DATA SYSTEM
Charles H. Vermillion 301-286-5111

The objective is to develop and deploy a data capture and distribution system for the Geostationary Meteorological Satellite (GMS) in Hawaii. Data will be accessed through networks and other communication systems. The system will be maintained for WETNET support. Studies will be provided that will lead to eventual design, development, and deployment on the INSAT system as well.

W91-70352 **578-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIATIONS OF GLOBAL SST
D. Halpern 818-354-5327

Sea surface temperature (SST) is an important boundary condition of atmospheric circulation. This research will determine the sensitivity of the University of California/Los Angeles (UCLA) atmospheric general circulation model (AGCM) to global monthly mean SST distributions complied from sparsely and unevenly sampled in situ observations recorded by ships and compiled from satellite measurements with very little aliasing. Over large geographical regions, differences of 1 to 2 C were found between the data sets derived from High Resolution Infrared Sounder (HIRS2) and Microwave Sounding Unit (MSU) (HIRS2/MSU data set) and from ship measurements called the Comprehensive Ocean-Atmosphere Data Set (COADS). The multi-decadal COADS SST data set is used frequently as a surrogate of global SST, even though the large amount of aliasing caused by inadequate sampling is well known. This research investigates the significance of the differences between global SST distributions derived from COADS and from satellites vis-a-vis their influence upon atmospheric circulation dynamics. If the simulated atmospheric circulations are statistically equivalent, then the reliability of the COADS SST data set for climate studies is enhanced. UCLA AGCM simulations with both SST data sets prescribed as boundary conditions will be compared with a control run involving only SST climatology. This research is conducted jointly with Professor C. Roberto Mechoso, UCLA, who is a Co-Principal Investigator.

W91-70353 **578-22-90**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TROPICAL OCEAN CIRCULATION FROM ALTIMETRY AND NUMERICAL MODELING
C. M. Perigaud 818-354-8203

The long-term objective of this RTOP is to investigate the utility of satellite altimetry for studying the tropical oceanic circulation and its variations. The current focus is Geosat altimeter data. The edited, geographically gridded Geosat data set is used for observations of sea level variations. The latter are simulated using different theoretical approaches (reduced-gravity model of the Indian Ocean, the Geophysical Fluid Dynamics Laboratory (GFDL) Ocean General Circulation Model (OGCM) over the tropical Pacific). Optimal estimation techniques (Kalman filtering and smoothing or adjoint models) are the main tools for analyzing the data in a given dynamical context. Both descriptive and modeling studies will be conducted. The first near-term objective is the comparison of Geosat observations with shallow-water model predictions in the Indian Ocean. The second objective is the comparison of Geosat observations with OGCM model predictions in the Pacific Ocean. The focus is instability waves along the shear front of the North Equatorial Counter Current. The third objective is to investigate methods for fitting ocean models to altimeter data. The initial focus is linear equatorial waves in the Pacific or Indian Oceans. This will involve optimal estimation of sea level using Kalman filtering scheme and optimal estimation of sea level and model parameters using an adjoint model.

W91-70354 **578-40-00**
Goddard Space Flight Center, Greenbelt, MD.
LARGE SCALE PROCESSES
Robert G. Kirk 301-286-7895

This RTOP covers interdisciplinary efforts to develop observing systems for large scale physical and biological processes affecting climate change.

W91-70355 **578-41-01**
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 is 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 processses or numerical schemes, using the previously developed Model 2 as a control for these experiments. Use of the current Model 2 for climate studies is 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 decadel time scales.

W91-70356 **578-46-13**
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, DATA ANALYSIS
G. S. Wilson 205-544-1628

The objectives of this RTOP are to maintain smooth and efficient performance of the Earth Science and Applications programs by providing programmatic flexibility; and to continue the design and development activities related to the Geoplatform portion of Mission to Planet Earth. The approach is to maintain a low level of funding to allow efficient correction of problems as they develop in the advanced studies. GEO development will continue with refinement of the science requirements, completion of system level and instrument Phase 1 definition studies and preparation for release of the Announcement of Opportunity for investigators. Initiation of Phase 2 activity is being prepared.

Biogeochemistry and Geophysics Modeling and Data Analysis

W91-70357 **579-20-00**
Goddard Space Flight Center, Greenbelt, MD.
NUMERICAL DIAGNOSTIC STUDIES OF THE ATMOSPHERE
J. R. Bates 301-286-7482

The objective of this research is to diagnose atmospheric quantities such as isentropic potential vorticity and its fluxes and other diagnostics to investigate the temporal variability of the atmosphere. In addition, a combination of conventional and satellite data will be utilized to study the impact of satellite data on an investigation of major anomalous weather events. Special emphasis will be placed on the impact of satellite data on understanding explosive cyclone development and displacement.

W91-70358 **579-21-44**
Langley Research Center, Hampton, VA.
BIOGEOCHEMISTRY AND GEOPHYSICS - DATA ANALYSIS
Ellis E. Remsberg 804-864-5823

The objective of this RTOP is the application of remote sensing technology and measurements for environmental monitoring of the middle atmosphere. Data analysis techniques and comparisons with models will be used to improve understanding of the middle atmosphere and potential changes to its composition and structure. Specific tasks include: (1) the analysis and comparison of satellite data sets for stratospheric NO2; (2) empirical model studies of perturbations and trends in middle atmosphere ozone and temperature; (3) the interpretation of chemistry and transport processes in the middle atmosphere using constituent and temperature data from satellite-based experiments; and (4) maintenance of a pilot electronic data base consisting of middle atmosphere trace gas data, plus temperature and geopotential height from both measurements and models to facilitate rapid dissemination of data to the scientific community and to support data and 2-D model intercomparisons.

W91-70359 **579-24-02**
Langley Research Center, Hampton, VA.
MODELING AND DATA ANALYSIS, BIOGEOCHEMISTRY AND GEOPHYSICS MODELING
William L. Grose 804-864-5820

The objective of this RTOP is to improve understanding of chemical, dynamical, and transport processes in the Earth's atmosphere. Investigation of these phenomena will be conducted through theoretical studies with a three-dimensional chemistry/transport model and concomitant analysis of global satellite observations.

W91-70360 **579-24-06**
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 of this RTOP are to (1) contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of human impact on atmospheric composition; and (2) determine measurement requirements and sampling strategies for tropospheric chemistry program, and aid in interpretation of observations. A series of studies is being/has been made with a 3-D Chemical Transport Model (CTM) developed from the GISS General Circulation Model and in collaboration with colleagues at Harvard University. The approach has been progressive; successive studies of different chemical species have led to a better understanding and calibration of the CTM: (1) chlorofluorocarbons (done); (2) krypton-85 (done); (3) radon (done); (4) methylchloroform (done); (5) methane (in progress); (6) carbon monoxide (in progress); and (7) odd nitrogen and ozone (in progress/planning).

W91-70361 **579-24-09**
Goddard Inst. for Space Studies, New York, NY.
CLIMATOLOGICAL STRATOSPHERIC MODELING
David Rind 212-678-5593

The objectives of this RTOP consist of (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 includes 3-D modeling of the troposphere/stratosphere/mesosphere system to deliniate climate change influence on the stratosphere; and saving results for use with photochemical models.

W91-70362 **579-31-01**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL FIELD SEPARATION
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. The approach consists of: (1) the development of suitable data selection and filtering criteria; (2) estimating or modeling external fields and correcting the data where possible; (3) collecting and collating alternative data for comparison and joint analysis; and (4) developing and evaluating analyses techniques.

W91-70363 **579-31-02**
Goddard Space Flight Center, Greenbelt, MD.
MAGNETIC FIELD MODELING
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 and FY-90 a total rewrite and modernization of the field modeling software was tested; an error analysis formulation was published; the field modeling data set was cleaned up, reorganized and documented. The usefulness of data from other satellites (DE-1, AMPTE) is being investigated. With Environmental Data and Information Service (EDIS)/NOAA, reduction of the marine magnetic data set for use in main field modeling was completed and published. An effort is underway to acquire marine data not now available to EDIS. A spline representation for secular variation has been incorporated into the fitting software and tested; a formalism for periodic functions will be attempted next year; a formalism for external field analysis will be incorporated in the coming year. Models were derived of both steady fluid flow and steady magnetic diffusion near the top of the core which fit definitive geomagnetic temporal variation better than did models of either process alone. Mantle conduction effects will be included to probe core dynamics, deep mantle conductivity, and improve the fit.

W91-70364 579-32-00

Goddard Space Flight Center, Greenbelt, MD.

CRUSTAL DYNAMICS SLR DATA ANALYSIS

Patrick H. McClain 301-286-2158

The purpose of data analysis is to use mainly the NASA Space and Earth Sciences Computing Center (NSESCC) computer systems to take Geodyn analysis of laser measurements and produce precise geodetic station coordinates in support of the Crustal Dynamics Project. The data reduction process includes the orbital analysis of Lageos ranging data and the results are enhancements to mathematical models. Lageos data has been re-analyzed in a global solution (SL7) for plate motion and regional deformation. Geodyn and other related programs such as Solve, produce station positions for the tracking network, determine polar motion, earth rotation, tidal parameters, gravity models, GM, length of day and earth orientation parameters, etc., from satellite data. These processes require a tremendous amount of computing capability, computer allocations, and data storage capacity. The efforts include the use of the IBM 3081, Amdahl V7, CDC Cyber 205, and the ETA10. The vector processing capabilities at the NSESCC have been used extensively to produce significant analysis and results for the ongoing Crustal Dynamics Project investigations. Essential for continuing improvements is the new supercomputer, the Cray Y-MP8/432, which will allow for faster and more accurate computing, the use of greater amounts of data, swifter turn around, and, combined with the IBM 3081 and the Terabyte machine, will provide a vast array of storage. This development will allow: improvements in computer networking for more efficient distribution of the data to the laser and other analysis groups; improvement in methods of using data; development of new software programs; and the improvement of the earth and ocean tidal model.

W91-70365 579-32-01

Goddard Space Flight Center, Greenbelt, MD.

GRAVITY FIELD AND GEOID

David E. Smith 301-286-8671

The objectives of this RTOP include the development of an improved model of the Earth's gravity field in combination with a model for the ocean tides, and a model for the dynamic ocean topography. The gravity, tidal and ocean topography models will be derived from a combination of tracking data, altimetry, and surface measurements. In order to better represent the shorter wavelengths in the gravity field of the Earth, the new field will be larger in degree and order than previous models (approximately 70 x 70). Primary emphasis will be placed on the incorporation of the high quality laser tracking data being acquired by NASA Crustal Dynamics Project, and the altimetry data from past and upcoming spacecraft. Extended force models for the dynamic polar motion, relativity, etc. will be incorporated into the solution so as to improve the modeling and understanding of the Earth and spacecraft motions. This activity is the geophysical component of a joint modeling and research program by the cognizant NASA Earth and Oceans Program offices.

W91-70366 579-32-01

Goddard Space Flight Center, Greenbelt, MD.

SOFTWARE DEVELOPMENT (GEODYN, ERODYN, SOLVE)

Barbara H. Putney 301-286-6018

The objective of this RTOP is to maintain, design, and develop the Geodyn, Erodyn, and Solve software to support the satellite orbit determination and parameters estimation needs of the Space Geodesy, Geodynamics Branches at GSFC as well as for scientists around the world. The goal is to determine orbits at the centimeter level by modeling all forces and measurements precisely. This software has produced the precision orbits for Seasat and Geosat in the past, and will produce them for Topex and SALT in the future. The Goddard Earth Models containing spherical harmonics for the gravity field, polar motion and earth rotation, station positions, GM of the earth and earth and ocean tidal components have been created with this software. The data types currently supported are range (laser), range rate (Doppler), difference measurements (GPS), satellite to satellite, angle and altimetry measurements. The objectives are to produce state-of-the-art precision orbit determination and parameter estimation software that runs efficiently on vector computers, that supports many appropriate data types, and can be moved easily to different computers. Force models will be updated as the information becomes available. Models currently being implemented and evaluated are time dependent sea surface topography, time dependent station velocities, albedo, sophisticated empirical acceleration parameterization, improved drag density, pole tide, local gravity, thermal drag and relativity models. Data types will be increased to include precise GPS modeling, altimeter crossovers, very long baseline interferometry (VLBI), and new Doppler type measurements. The software will be migrated and optimized for the Cray YMP computer. Software will be created that is portable, well documented, and well tested.

W91-70367 579-32-02

Goddard Space Flight Center, Greenbelt, MD.

SPECIAL STUDIES FOR GRAVITY FIELD IMPROVEMENT

David E. Smith 301-286-8671

This RTOP addresses the development of new techniques and the application of existing methods to the determination of the accuracy of present gravity fields and improvement that can be accomplished with new or additional data. Present knowledge of both the long and short wavelength static field will be studied and so will the ability of new data from future missions be assessed for time variations in the planetary scale terms. The principal method that will be applied is that of data simulation and analysis of the covariance matrix. This approach will be applied to the Aristoteles mission for both the gradiometer measurement and the Global Positioning System (GPS) tracking. The equivalent of several months of data will be simulated and analyzed as real data, and the resulting covariance used as a measure of the importance of the data set to improving the gravity field.

W91-70368 579-34-01

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

IMAGE PROCESSING CAPABILITY UPGRADE

R. E. Alley 818-354-6363

The objective of this RTOP is to upgrade the facilities available to the geology group for image processing and for analysis of field samples. The current operational image processing and analysis computer system consists of two machines. One is a VAX 11/750, with 1.2 gigabytes of disk storage, one tri-density high speed tape drive, one medium density tape drive, an HP 9872S flatbed pen plotter, and a color interactive image processing workstation. The other computer is a Sun Sparcserver 4/370, with 1.4 gigabytes of disk storage, and controllers for two additional disk drives, two tape drives, and an image processing workstation. Access to these computers may be accomplished directly via 8 terminals, or indirectly via 3 telephone line modems, ILAN (the

JPL local network), DECNET, and ARPANET. Upgrades to the geology group's facilities that are required this year include the transfer of disk, tape, and image display peripheral devices from the VAX to the Sun computer, the purchase of a high density backup/archive 8 mm cartridge tape system and a flatbed plotter, in addition to maintenance services for the Sun computer and the Beckman visible-near infrared spectrophotometer. The approach to be taken consists of the transfer of all usable peripherals from the older VAX 11/750 to the newer and faster Sun 4/370. An 8 mm tape cartridge archival and backup system will be purchased to alleviate the present problems (in both space and organization) of data storage. A pen plotter, software compatible with the plotter currently on the VAX, will be added to the Sun. An additional plotter may be needed for use with x ray diffraction analysis software. Hardware and software maintenance services will be provided for the Sun and for the spectrophotometer. Since the removal of most peripherals will make the VAX unusable at or before the start of FY-91, no maintenance will be provided to that machine in FY-91.

W91-70369 **579-40-00**
Langley Research Center, Hampton, VA.
BIOSPHERIC/ATMOSPHERIC INTERACTIONS
Joel S. Levine 804-864-5692

The Wetlands Project study will establish relationships between CO2 exchange and remote sensing parameters in wetlands vegetation photosynthesis and corresponding canopy reflectance characteristics. The Global Biomass Burning and Biogenic Gases is a field measurement program to quantify particulate and gaseous emissions from biomass burning, to quantify pre- and post-burn biogenic gas emissions, and to quantify the global/areal extent of biomass burning from satellite images.

W91-70370 **579-41-02**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-286-7122
(199-30-90)

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, 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.

W91-70371 **579-41-04**
Goddard Space Flight Center, Greenbelt, MD.
LTP COMPUTER SUPPORT
Edward Masuoka 301-286-7608

The objective of this RTOP is to provide the best possible computing environment for scientists in the Laboratory for Terrestrial Physics (LTP), who are conducting research in Land Processes. The following approaches will be used: (1) maintain a highly interactive computing environment on the Laboratory VAXcluster to insure that scientists have access to familiar tools for image processing, data analysis, and visualization and that users with scientific workstations can make effective use of disk storage in the main computer facility; (2) provide system administration and networking support for scientists with UNIX workstations; (3) improve analysis capabilities for existing workstations in the LTP by obtaining a common suite of software for graphics and image processing; and (4) assist RTOP managers by providing timely financial data through an online database maintained on the LTP VAXcluster.

W91-70372 **579-42-01**
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 investigate the influence of land-surface processes on the climate change. The analysis of sixteen model simulations for the summer and winter conditions with the SiB-General Circulation Model (GCM) led to the understanding of several deficiencies of GLA GCM simulations. The model had a significant problem with the radiation balance at the surface and the top; it was drying with excessive initial precipitation leading to severe spinup problems, and its absorption of solar radiation in the atmosphere was too little. A systematic evaluation of these problems led to improvements in implementation of the Arakawa-Schubert cumulus scheme in the model. The radiation calculation was revamped to make the radiation handle clear and partially cloudy conditions in the atmosphere consistently; and to make the surface radiation budget realistic, we included climatic distribution of aerosols in the model. This model is now at a stage where several simulation studies can be conducted on the influence of earth-atmosphere interactions on climate.

W91-70373 **579-42-01**
Goddard Space Flight Center, Greenbelt, MD.
MODELING AND MULTISPECTRAL SATELLITE DATA ANALYSIS FOR LAND SURFACE STUDY WITH EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS
B. J. Choudhury 301-286-5155

The objective of this RTOP is to quantify seasonal and inter-annual variations of surface wetness, temperature, microwave polarization difference and spectral vegetation indices over hot arid and semi-arid regions of northern Africa and southeastern Australia for the period 1979 to 1988 using Scanning Multichannel Microwave Radiometer (SMMR), Advanced Very High Resolution Radiometer (AVHRR), Thematic Mapping (TM), and Special Sensor Microwave/Imager (SSM/I) data; and perform radiative transfer and heat balance simulations to understand this data in terms of land surface prognostic and diagnostic variables. A predictive model for surface wetness will be developed based upon SMMR 6.6 and 37 GHz data and tested over an independent region within the U.S. Southern Great Plains. Then the SMMR data will be used to produce soil moisture maps for northern Africa and southeastern Australia for 1979 to 1987. Radiative transfer and heat balance models will be used with hourly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices and surface temperature. The simulated relations between the multispectral data will be compared with the observed relations to evaluate the relative sensitivity to varied surface and environmental characteristics.

W91-70374 **579-42-03**
Goddard Space Flight Center, Greenbelt, MD.
TOPOGRAPHY FROM SEASAT AND GEOSAT OVERLAND ALTIMETRY
Herbert Frey 301-286-5450

The objectives of this RTOP are to determine the accuracy and quality of topographic data that can be derived from SEASAT and GEOSAT overland altimetry on a global basis; develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and demonstrate utility of satellite-derived topographic data for both geological and geophysical problems. The approach is to evaluate the usefulness of merging many repeat cycles of GEOSAT data into a single average profile; retrack selected portions of the GEOSAT overland altimetry data and merge this with the data already produced by us from the SEASAT mission; produce selected regional maps of combined GEOSAT and SEASAT-derived topography for use in geological and geophysical studies; evaluate the accuracy of these 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 assess the utility of the satellite-derived data for geophysical problems such as the mechanism of compensation of the Himalayas and other large continental structures, and for geological problems such as the difference between ancient and modern stream gradients for the Chad Basin and the temporal change in water level in the Amazon.

W91-70375 **579-42-04**
Goddard Space Flight Center, Greenbelt, MD.
PILOT LAND DATA SYSTEM (PLDS)
Blanche W. Meeson 301-286-9282

One of the objectives of this RTOP is to provide the land science community with a distributed data system to support their research. This data system, the Pilot Land Data System (PLDS), will provide them with a means to determine what data is available, where it is located, help them to acquire that data, help them to access remote computer facilities where they might access the scientific data, process the data or display it, and finally, help in the preparation and publication of data sets. In FY-91 this objective will be pursued by adding significantly to the data described in the PLDS inventories, by providing more thorough documentation, by improving the performance of the users' environment, by assisting data producers with preparation and publication of their data sets, and by beginning a small-scale operational phase.

W91-70376 **579-43-00**
Ames Research Center, Moffett Field, CA.
TROPICAL LAND USE CHANGE AND NITROGEN TRACE GASES
P. A. Matson 415-604-6884
(199-30-62)

The objective of this research is to determine the extent to which tropical agriculture, pasture, and fertilizer use contribute to the global increase of nitrous oxide. Furthermore, this research will determine the fractions of nitrogen flux to the atmosphere in nitrous oxide, nitric oxide and ammonia, as a function of soil fertility and vegetation canopy characteristics. The approach is to measure nitrous oxide fluxes and controlling soil processes in a variety of natural and agricultural systems in Brazil, southeast Asia, and Hawaii. Sites will be selected within a matrix of common management practices. Global models that estimate fluxes based on soil type, temperature and moisture regimes, vegetation activity, and land use will be developed. Research on the fractions and controls of relative nitrous oxide, nitric oxide and ammonia fluxes will be carried out experimentally in well-studied agricultural research sites in Hawaii, and will include soil flux estimates, eddy correlation flux estimates between canopy and atmospheric remote sensing and model development at both soil and canopy levels.

Radio Science and Support Studies

W91-70377 **643-10-01**
Lewis Research Center, Cleveland, OH.
SPECTRUM AND ORBIT UTILIZATION STUDIES
James W. Bagwell 216-433-3502

The objectives of this RTOP are to: (1) provide technical consultation services support in the area of space communications services with particular emphasis on preparing for international meetings relating to the fixed satellite service (FSS), the broadcast satellite service (BSS), and the mobile satellite service (MSS); (2) provide the technical basis and regulatory support needed to obtain sufficient orbit/spectrum to meet current and projected requirements of NASA and the United States; and (3) perform studies, develop analytical methods for spectrum management, conduct evaluations, identify technology status and needs, perform critical technology developments, perform measurements (where necessary) to determine sharing criteria, and evaluate alternatives that result in efficient and cost effective use of the geostationary orbit/spectrum resource. Specifically, these activities will support planning for NASA and other government agencies' communication needs. They will also support participation in technical meetings of the Consultative Committee for International Radio (CCIR), Consultative Committee for Space Data Systems (CCSDS), and the Consultative Committee for International Telephone and Telegraph (CCITT) with primary emphasis on the FSS and BSS, and secondary emphasis on the MSS and the ISDN as well as participation in other national and international groups that set standards for data transmissions. The described activities will be conducted 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. A combination of in-house and contract activities are planned.

W91-70378 **643-10-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPAGATION STUDIES AND MEASUREMENTS
F. Davarian 818-354-4820
(679-00-00; 650-20-22)

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 specifications of space communication systems. Therefore, the goals of this RTOP are to quantify the propagation effects through field tests to develop prediction models, substantiate the existing models for cases where no experimental data exist, and provide support to the Consultative Committee for International Radio (CCIR) and other regulatory bodies. The objectives of this RTOP can be achieved through a three part work plan: (1) propagation measurements and experiments from about 0.5 GHz to about 100.0 GHz; (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. Propagation measurements are made during field tests and through participation in such programs as the Advanced Communications Technology Satellite (ACTS) Experiment, the Olympus Experiment, the Mobile Satellite Experiment (MSAT-X), and the direct sound broadcast study. The second activity, which includes simulation, modeling, and fade countermeasure efforts, is performed by analyzing the results of the first activity and publishing the findings. The third activity typically includes CCIR contributions, surveys, and the propagation handbooks for Earth-space paths. Collaboration and information exchange between domestic and international laboratories will continue. The tasks of this RTOP are carried out primarily at universities and government laboratories.

W91-70379 **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 provide new system concepts and to identify key technologies leading to the growth of advanced communications satellite system services which will be compatible with existing space and terrestrial services. The technical objectives of this RTOP for FY-91 are (1) to explore new communications satellite concepts, with the main thrust being the development of a satellite sound broadcasting system; (2) to study system concepts leading to a satellite-aided personal communications system; and (3) to assess state-of-the-art communications satellite technologies. This RTOP will primarily focus on the development of system design concepts for a satellite sound broadcasting service and address issues such as modulation, diversity, and receiving terminal design cost. Supporting analyses, mainly in modulation and coding, will also be performed. The results of these satellite sound broadcasting studies will be provided to the broader NASA/Voice of America (VOA) joint activity aimed at world wide satellite broadcasting. The JPL mobile channel simulator will be upgraded to support laboratory testing of satellite sound broadcasting hardware and future communications satellite projects such as Ka-band Mobile. Studies will be conducted to establish a system concept for a space/ground personal communications hybrid network that can meet the technical and economic challenges of telecommunications of the 21st century, which is characterized by diversity of services, choice of media, and automatic signal routing. The technology being developed for high frequency communications satellites such as Advanced Communications Technology Satellite (ACTS), Engineering Test Satellite-6 (ETS-6), Olympus, etc., as well as L-band mobile satellites, 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 communications and satellite sound broadcast reception.

W91-70380 **643-10-05**
Lewis Research Center, Cleveland, OH.
COMMUNICATION SATELLITE STUDIES
James W. Bagwell 216-433-3502

The objectives of this effort are to identify and define new applications/services 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).

W91-70382 **646-76-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS
James R. Lesh 818-354-2766
(310-20-67; 506-44-21)

This RTOP is aimed at the development of component and system-level technologies for use with future optical communication system equipped applications. The RTOP consists of two work units: the Optical Communication Systems Technology work unit, which focuses on the development of solid-state laser based coherent optical communication systems, and the Advanced Materials Technology Application work unit, which focuses on the development of composite materials structures for future optical communication systems. Activities in the Optical Communication Systems Technology work unit through FY-90 include the characterization and test of frequency stabilized lasers, the design and implementation of an optical phase tracking loop, and the development of a laboratory link demonstration operating at 100 kbps, with emphasis on carrier tracking with a weak incident signal power. Specific technical objectives for this work unit in FY-91 are (1) to complete a link demonstration employing coherent phase shift-keying modulation format; (2) to extend the operating range of the architecture to 100 Mbps; and (3) to incorporate the spatial tracking subsystem into the existing communication demonstration. On-going activities for the Advanced Materials Technology Application work unit through FY-90 include: (1) generation of estimates of orbital thermal environment for a typical application; (2) estimates of typical element alignment requirements; (3) development of optical bench detailed design and performance prediction models; and (4) fabrication of a breadboard bench based on size and alignment requirements of a typical optical communication system. During FY-91, this work unit will address thermal evaluation of the breadboard bench, comparison of the measured and projected mechanical performance such as thermal stability and stiffness, refinement of the breadboard design based on actual test results, limited orbital thermal simulation testing of breadboard bench, and analytical projection of full scale hardware performance.

Communications Data Analysis

W91-70381 **646-10-01**
Lewis Research Center, Cleveland, OH.
APPLICATIONS EXPERIMENTS PROGRAM SUPPORT
James W. Bagwell 216-433-3502

The objectives of this RTOP are to: (1) coordinate with other Federal agencies and public and private sector organizations in the development of experimental satellite communications activities for emergency/disaster communication and public and private service applications; (2) assist users in the transition from the NASA experimental satellites to commercial satellites where continuity of service can be assured; (3) demonstrate satellite communication technology using experimental satellites such as Applications Technology Satellite (ATS) and Advanced Communications Technology Satellite (ACTS), and other satellites of opportunity for other governmental agencies and the public service and private sectors; (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 users' needs requiring the development of new technologies.

Advanced Communications Research

W91-70383 **650-20-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOSTATIONARY COMMUNICATION SATELLITE ENVIRONMENTAL DESIGN CRITERIA HANDBOOK
A. J. Beck 818-354-4575
(643-10-03; 643-10-04)

The objective of this RTOP is to produce a handbook containing information and data that the geostationary satellite designer can use to determine specific estimates of environmental parameters and/or algorithms which can be used to determine design criteria associated with long life, high reliability spacecraft. The process is based on techniques used to establish environmental estimates and design criteria used in the design of spacecraft for near and deep space missions where reliable operation is required for extended periods of time exceeding ten years. Many factors in the design process contribute to extending the life and improving reliable operation of the satellite; the environmental design criteria are considered to be such factors. The handbook will consist of two parts. The first part will address the electromagnetic environment from the viewpoint of the designers and users of geostationary telecommunications systems. This will provide the tools, methodology and information needed to cope with the electromagnetic environment that exists in the vicinity of geostationary orbit. The second part will address the physical environment to which geostationary telecommunications systems would be subjected. The second part, the Physical

Environment, will contain specific procedures for evaluating estimates of environmental parameters for the ambient physical environment and for determining environmental design criteria for communication satellites designed for geostationary orbits. An algorithm will be presented for specifying the design criteria. These procedures for establishing environmental design criteria have been developed over the years for deep space spacecraft and have contributed to extending the life and reliability of these spacecraft. These same procedures could contribute to the communication satellite technology and could be useful to both government and commercial geostationary satellite suppliers.

W91-70384 **650-60-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MOBILE COMMUNICATIONS TECHNOLOGY DEVELOPMENT
William Rafferty 818-354-5095
(643-10-03; 643-10-04)

This is an on-going technology development program aimed at the efficient use of orbit, spectrum and equivalent isotropically radiated power (EIRP) for mobile and personal satellite communications systems. At L-Band, MSAT-X (Mobile Satellite Experiment) has concentrated on several areas of technology. Developments in medium gain antennas, speech coders, modulation and networking were successfully demonstrated. The current thrust of MSAT-X is the transfer of this technology to industry. To implement the technology transfer, NASA and JPL are encouraging other government agencies to use capacity on the commercial system for technical and operational experiments. This capacity will be derived from a bartered launch agreement with the America Mobile Satellite Corp. (AMSC). At Ka-Band, the Personal Access Satellite System (PASS) will focus on fixed and land-mobile satellite communication terminals for experimentation with the Advanced Communication Technology Satellite (ACTS). This involves the development of variable rate speech codecs; variable rate, power efficient modems; Ka-Band transceivers; and antennas. This activity, the ACTS Mobile Terminal (AMT), shares many common link technology goals identified for PASS. The AMT experiments with ACTS are planned for FY-93 to determine mobile system performance and to validate the various algorithms developed under this activity. These activities are accomplished through in-house JPL efforts and a mix of industry and university contracts. A series of MSAT-X field experiments are on-going and have validated mobile satellite systems (MSS) system concepts and operational equipment. The MSAT-X technologies were successfully developed to the breadboard level and are already being phased into the evolving U.S. MSS at the system definition level. AMT will concentrate on the high risk technologies associated with the use of Ka-Band frequencies. Technology development in variable rate speech encoders and modems, radio frequency (RF) components, including transceiver elements and medium gain steerable antennas, and integrated mobile terminals will be pursued. Laboratory and field experimentation will also be conducted.

W91-70385 **650-60-20**
Lewis Research Center, Cleveland, OH.
SPACE COMMUNICATIONS SYSTEMS ANTENNA TECHNOLOGY
James W. Bagwell 216-433-3502
(650-60-22)

The objective of this RTOP is to conduct research and technology development on antenna systems and components for commercial space communication systems. 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 characteristics, printed circuit radiating elements, applications of optics in arrays, and system analysis will also be developed. Emphasis will be on MMIC device integration/insertion technologies applicable to single beam array systems in the near term and ultimately extendable to multiple beam systems in the future.

W91-70386 **650-60-21**
Lewis Research Center, Cleveland, OH.
SATELLITE SWITCHING AND PROCESSING
James 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)/expert systems and neural networks.

W91-70387 **650-60-22**
Lewis Research Center, Cleveland, OH.
RF COMPONENTS FOR SATELLITE COMMUNICATIONS SYSTEMS
James 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. This RTOP will utilize both contracted and in-house efforts to: (1) develop analysis and synthesis techniques for the above space program components; (2) apply the developed techniques to determine the basic characteristics of components meeting specified requirements; (3) fabricate proof-of-concept components; and (4) test and evaluate fabricated components.

W91-70388 **650-60-23**
Lewis Research Center, Cleveland, OH.
COMMUNICATIONS LABORATORY FOR TRANSPONDER DEVELOPMENT
James W. Bagwell 216-433-3502
(650-60-20; 650-60-21; 650-60-22)

The objectives of this RTOP are (1) to develop, operate and maintain communications laboratory facilities for in-house development, integration, test evaluation and demonstration of advanced space communications technology; (2) to develop, operate and maintain communications network test beds for integrating in-house, contract and grant developed subsystems and demonstrating performance and advanced technology readiness; and (3) to design, develop and test prototype space and ground segment technology components and subsystems in-house that employ state-of-the-art radio frequency (RF) and digital systems technologies. The activities of this RTOP are (1) to design, develop, test and demonstrate Ka-Band and other extremely high frequency (EHF) translation technologies; (2) to develop and demonstrate time division multiple access/time division multiplexed (TDMA/TDM) and frequency division multiple access (FDMA)/TDMA/TDM link technology for fixed and scanning spot beam communication links; (3) to design, and demonstrate space and ground based switching and processing technologies for video, data, and voice employing TDMA/TDM and FDMA/TDMA/TDM communication links; (4) to develop and demonstrate digital modem, multichannel demodulator, information switching processor and autonomous control enabling technologies in-house; (5) to apply expert systems and neural network technologies to both the space and ground segments; and (6) to support specific Advanced Communications Technology Satellite (ACTS) testing needs, ground terminal development, and the experiment program.

Data Systems

W91-70389 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 and at related workshops, conferences, and meetings. Technical and policy review are provided by JPL's Office of Space Science and Instruments and by NASA Headquarters.

W91-70390 656-61-01
Goddard Space Flight Center, Greenbelt, MD.
DATA SYSTEM INTEROPERABILITY
James R. Thieman 301-286-9790

The objectives of this RTOP are (1) 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; and (2) to enable efficient distribution of up-to-date information about data throughout the systems by applying metadata standards. In a continuing effort (now being transferred to institutional funding) coordinated by the National Space Science Data Center (NSSDC), representatives from participating data information systems work together toward implementing interoperability in the following steps: determine, together with a science advisory group, requirements for interoperability; develop a standardized Directory Interchange Format (DIF) for passing information among the data systems for input and update of directory-level information; develop, operate, maintain, and continually improve a Master Directory which has a comprehensive set of space and earth science data set descriptions entered via the DIF; assure the quality, consistency, and completeness of directory-level information by a discipline scientist review process; 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; 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 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.

W91-70391 656-61-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA SYSTEM INTEGRATION (COMMONALITY AND INTEROPERABILITY)
L. E. Preheim 818-354-5041
(656-61-03)

Nearly a decade of experience with the Office of Space Science and Applications (OSSA) 'Pilot' data systems has taught us that there are many data system functions which are broadly applicable and independent of the science discipline supported by the data system. We have also seen a trend toward decentralization of data system implementations, implying that there will be a need for a great many small, cooperating, independently developed data systems to support future OSSA 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 modules. This RTOP continues a process, which has been proven by unusually successful experience (viz., directory interchange format and context passing development) in the intercenter, interagency, and international domains, for systematizing the experience of the data systems community in the form of a standard set of basic data system requirements, a widely accepted system reference 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 systems or the addition of important functions to existing data systems. The task proposed will (1) use an already completed Requirements Commonality Study (JPL-D-7187) Conceptual Reference Model and draft Building Block Plan to further identify potential portable software modules for adoption as standard building blocks; (2) capture and document several existing, operationally proven building blocks; (3) produce at least one new building block which instantiates a high payoff commonly used function; and (4) demonstrate these modules by arranging for their incorporation, use, and evaluation in new or expanding OSSA data systems. This RTOP will cooperate with, support and make use of the results of RTOP 656-61-03 (Data Interchange Standards) and the Catalog Interoperability/Master Directory Project (POP funded).

W91-70392 656-61-03
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA INTERCHANGE STANDARDS
M. L. MacMedan 818-354-7004

The purpose of this RTOP is to develop standard methods for organizing (grouping) and identifying information with the long range objective of facilitating automated, generic services. An associated task, the Control Authority, registers identifiers for formats and data description languages, preserving and disseminating these definitions. This helps contemporary or future users of the data to have recourse to the definitions even if they were not necessarily the ones who generated the data. The work is based on the Standard Formatted Data Unit (SFDU) Concept, a technique under development by NASA in cooperation with 17 other space agencies of the world who are part of the Consultative Committee for Space Data Systems (CCSDS). Previous work has developed the necessary concepts and standards; the RTOP this year will refine these concepts in accordance with projects' needs. In addition, it focusses on: (1) understanding the SFDU system environment and architecture at JPL; (2) the development and demonstration of standard software tools to provide services for users working with SFDUs and other activities directly in support of projects at JPL; and (3) development of service utilities to be used with Transfer Syntax Description Notation (TSDN), a language developed under this program with unique capabilities that address the problems of data format descriptions. One approach of this RTOP will be to develop a SFDU architecture for the JPL environment, using good system engineering practices. This architecture will identify providers, users, functional nodes, services and interface formats to be provided at each node. In particular, it will determine requirements for software tools which will provide automated services for user operations. This RTOP will also continue the development of standard portable software tools for creating, manipulating, displaying and managing SFDU products. TSDN builder and parser software tools will be developed to enable users of this data-description language to describe and interpret their user data sets at the Fundamental Support Level. Future tools will lead to automated capabilities to accomplish this. This RTOP will also provide application engineering support for using these standards to JPL projects (MO, MGN, TOPEX, NAIF, PDS, etc.) and develop internal JPL SFDU standards for information interchange and archive.

W91-70393 **656-61-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NAVIGATION ANCILLARY INFORMATION FACILITY
C. H. Acton 818-354-3869

This RTOP develops and tests prototype software and data management technology, collectively called the SPICE (Survey Probe Infrared Celestial Experiment) 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. Accommodation is also made for requirements that pertain to planning such scientific observations. The work is conducted in direct response to recommendations of the National Academy of Sciences' Committee on Data Management and Computation. It is particularly relevant as instrument complexity, instrument data volume, and interest in correlative analysis all grow. The work supports the objectives of reduced mission cost using remote 'telescience' concepts. The National Ancillary Information Facility (NAIF) development approach follows recommendations to keep the science community involved in all stages of SPICE development, and to provide prototype component capabilities to scientists for testing in ongoing research applications. In addition, with a major role in supporting flight projects, NAIF ensures that its SPICE standards and methodology are consistently applied across the active mission and post-mission time frames.

W91-70394 **656-61-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM - DATA DISTRIBUTION AND ARCHIVE TECHNOLOGY
M. D. Martin 818-354-8751
(155-88-00; 656-61-05)

The overall objective of this RTOP is to improve data distribution and archive technology and methods for science data systems. The Planetary Data System (PDS) is used as the initial test-bed, but the technology and methods developed are applicable and are to be applied to data systems of all disciplines. There are two parts to this RTOP. The objectives of the first part are to develop and implement a Data Distribution and Archive Lab at JPL. This facility will: (1) provide assistance to the PDS and other NASA programs in distributing new or existing data sets on CD-ROM disks; (2) develop or adapt a basic set of software tools for preparing and accessing data sets distributed on CD-ROM; (3) continue to develop the Distributable Data System concept, where CD-ROMs contain full sets of documentation, catalog, geometry, software, and data; and (4) evaluate optical and magnetic data storage media for both data distribution and archival storage. As a complement to the technology enhancement objectives, an equally important objective is to improve the methods of how the Office of Space Science and Applications (OSSA) plans for and actually transfers mission archive data into long term archives, especially attacking the problems posed by very large data volumes and transfers from flight projects with distributed architectures to distributed data systems like PDS. This effort will support Planetary Data System data preservation work. It will also coordinate with and support archiving efforts of other data systems (NSSDC, PDS, NODS, MIPL, FIST, SAR, etc.) to avoid duplication of effort. All tools will be developed to run on off-the-shelf computers (PC, Mac, Vaxstation, Sparcstation) to allow wide distribution and utilization by the science community. To improve the methods for science data archiving, the approach is to plan and prototype large volume and electronic science/catalog transfer techniques using current standards and actual flight project data and teams.

W91-70395 **656-61-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA PRESERVATION
S. LaVoie 818-354-5677

The objectives of this RTOP are: (1) inventory and evaluate all tapes (135,000); (2) preserve valuable data and make the data more accessible to the user; (3) reduce the volume of tapes by converting to a higher density media and disposing of duplicate data; and (4) transfer converted tapes and archive responsibility to the Planetary Data System or the National Space Science Data Center (NSSDC). Phase 1 - Inventory and Evaluation (begun in FY-90) includes the following activities: (1) recall all tapes; (2) organize, inventory, and catalog tapes; (3) evaluate tape values under guidance of Science Data Evaluation Board (representatives from science and technical community knowledgeable about the data); (4) prepare valuable data for conversion, distribute or dispose of duplicate data; and (5) publish Phase 1 report. Phase 2 - Conversion (estimated 3 years) consists of: (1) convert all valuable data to higher density media; (2) generate catalog of tape contents; (3) transfer tapes and archive responsibility to Planetary Data System or NSSDC; and (4) publish task final report.

W91-70396 **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' the National Space Science Data Center (NSSDC), in the permanent archiving of data from the Spaceflight Mission of the Microgravity and Life Science Program Offices of the Office of Space Science and Applications (OSSA). The study supported by this RTOP will determine data volume requirements for the permanent archives, data access requirements including what data needs online accessibility, and what data processing, manipulation, subsetting, reformatting, display, etc., capabilities must be provided by a permanent archive. It will determine whether HQ/EC should 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.

W91-70397 **656-61-17**
Goddard Space Flight Center, Greenbelt, MD.
NSSDC ASTROPHYSICS DATA SYSTEMS SUPPORT
Michael E. VanSteenberg 301-286-7876

The purpose of this project is the continued development and utilization of technologies that help the National Space Science Data Center (NSSDC) support the Astrophysics Data System (ADS) effort. The scope of this RTOP is divided into three parts: ADS Node Management, ADS maintenance and new utility development, and ADS Documentation Management. With ADS Node Management, we will continue our management support of the NSSDC ADS node. The NSSDC provides one of the primary ADS nodes. This node is used for remote user access to the Astronomical Data Center (ADC) catalogs, for remote terminal access to the ADS directory service (via SPAN, Internet, X.25, and dialup), for connectivity to the NASA Master Directory, and for factor space document processing. This node is also used as the non-astrophysics user interface into the ADS. With ADS maintenance and new utility development, we plan on providing the necessary maintenance of the NSSDC provided software components to the ADS and to develop and incorporate the new, but necessary, utility: data browsing tools, for the ADS. Specifically, the NSSDC provides and maintains the DAVID software package. This package is used for remote database management system (DBMS) access to all the ADS nodes. With ADS Documentation Management, we plan to develop the following capabilities in support of the ADS community: (1) digitization of textual data and pertinent documentation for the ADS; (2) processing of documentation for inclusion in the ADS directory service; (3) maintenance and storage of digitized textual data; (4) formatting and media preparation for distribution of textual data; (5) distribution of textual data and documentation by request; and (6) provision of on-line access to pertinent TBD textual data. This service will be used for the factor space processing of all ADS directory service material, for the maintenance and distribution of this material, and for the development of capabilities needed to manage and perform this task.

W91-70398 **656-61-18**
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS DATA SYSTEM
Robert E. McGuire 301-286-7794

A primary goal of NASA space science missions is the collection and analysis of scientific data. Recent experience in the NASA science community strongly argues that a discipline-oriented data system can significantly enhance the ability to both adequately archive and effectively access the most valuable of these data products. Such a discipline-oriented data system has not been previously defined or implemented for the support of the disciplines within the Space Physics Division. This multi-year RTOP is intended to be the vehicle by which the definition, design, and initial implementation of a new Space Physics Data System (SPDS) can be accomplished. Direction of the effort will be by the SPDS Steering Committee (SPDSSC) appointed by NASA Headquarters. Elements of the initial plan include: (1) support for the initial definition of scope and priorities of the SPDS, including preparation of background materials on relevant existing and planned data systems and preparation of 'strawman' scenarios for the scope and initial approach to the SPDS effort, as one input to the SPDSSC; (2) support for initial SPDSSC data set assessment and prioritization efforts; and (3) design and implementation of elements of the SPDS as directed, including as one possible immediate example a SPDS Catalog and Inventory System and its metadata contents.

W91-70399 **656-61-19**
Goddard Space Flight Center, Greenbelt, MD.
UNITED NATIONS ENVIRONMENTAL PROGRAM/GRID
Yun-Chi Lu 301-286-4093
(656-65-01)

The objective of this RTOP is to improve science and applications access to regional, continental, and global scale information by supporting technical requirements of the United Nations Environment Program/Global Resources Information Database (UNEP/GRID). The approach is to provide data handling capabilities that are on request by UNEP/GRID including: implementing existing interfaces between diverse data handling systems on UNEP computer systems, providing friendly user interface to NASA's LOWTRAN atmospheric correction software and writing new software to read specific data formats, register data to specified map projections, and display tabular data reports, maps, and imagery as required by UNEP. Long term technical and informational support of delivered systems will be provided by NASA on an institutional basis and training of UNEP staff will be provided.

W91-70400 **656-65-03**
Goddard Space Flight Center, Greenbelt, MD.
GENERIC VISUALIZATION OF SCIENTIFIC DATA
Gregory Goucher 301-286-2341

The objective of this research is to develop a data 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-91, the strategy is to continue to expand this operational system to include new visualization techniques and implementations in heterogeneous (UNIX, etc.) environments. Furthermore, new spatial data structures, such as the sphere Quad-trees, will be studied and applied to the data management aspect of complex data sets. 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 (CDAQ) and the NASA Climate Data System (NCDS), as well as individual NASA/GSFC scientists.

W91-70401 **656-65-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGING METHODS FOR MULTI-DIMENSIONAL SCIENTIFIC DATA VISUALIZATION FOR EARTH AND SPACE SCIENCES
Kevin J. Hussey 818-354-4016
(656-65-05; 677-43-21)

This task will develop the 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. The purpose is to assist scientists in their research. Earth scientists, planetologists, and astrophysicists must think in several dimensions to solve many of their problems, yet most data are represented in two dimensions. Interactive tools will be developed in a workstation environment to properly combine and then visualize multidisciplinary data in several dimensions. These tools will include volume visualization and analysis, two- and three-dimensional animation and analysis, metadata visualization and morphometric feature extraction. 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. By using a task team consisting of the scientists whose data is to be visualized, a visualization specialist and an image processing/computer graphics programmer, visualization capabilities will be extended in a manner consistent with achievable technology and scientific validity/utility. The software will be designed and implemented for portability and extensibility (i.e., generic X-windows implementations) using commercially available general purpose computing platforms (Sun 4's). Whenever practical, this RTOP will incorporate the Linked Windows Interactive Data System (LINKWINDS) analytical capability and build on existing (commercial, public domain and other JPL resident) software. This includes a 'scientist friendly' user interface. Additional data structures will be coregistered by extending existing techniques and development of new ones. We will generalize the methods, techniques and tools developed in previous FY's to handle a broad range of scientific data and deliver them to scientists for feedback. Due to the true 3-D nature of scientific data, the use of volumetric data visualization techniques will be incorporated.

W91-70402 **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 long-term objective of this task is to apply computer graphics technologies and methods to enable the display, manipulation, and analysis of large datasets. The development of computers with the power to calculate more and more models of ever-increasing complexity, and remote sensors with very high spatial, spectral, and temporal resolutions, threaten to swamp scientists. The contribution of computer graphics is that it brings the unique pattern recognition capabilities of the human eye/brain system to bear on this flood of data. The near-term objective is to provide a set of tools which permit the scientist to graphically display and interpret multidimensional, multivariate data, either alone or in collaboration. The system must permit quantitative as well as qualitative analysis. The approach taken here is to design and implement a computing and display environment, using off-the-shelf hardware combined with specially developed software, which enables simultaneous interaction with (and linked display of) multiple large complex datasets. The product is called Linked Windows Interactive Data System (LINKWINDS). It was initiated using support from the JPL Director's Discretionary Fund. LINKWINDS will permit multiple software applications to interact with a user under his/her control. The applications and their data can be manipulated in a series of co-varying windows for the study of trends, variations, anomalies, and correlations. The development process will be iterative. Applications are to be prototyped rapidly in the LINKWINDS environment and applied to specific data analysis tasks by users. The results are then fed back for the next stage of development. The system will eventually contain tools for allowing users to create their own applications.

W91-70403 656-65-06

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

SOLAR SYSTEM VISUALIZATION (SSV): SCIENTIFIC TOOLS FOR NASA/JPL IMAGE ARCHIVES

E. M. DeJong 818-354-3707

(656-65-04; 656-61-07; 656-74-03; 196-41-71)

The first objective of this task is to develop specific new scientific tools for use with the NASA/JPL solar system exploration archive. We propose to create a set of analysis, visualization, and data assimilation tools for use with this archive. Another objective is to create a computer 'environment' (combining the tools, workstations, networks, optical disk technology, and system software) which allows scientists to personally control all aspects of the analysis, visualization, and data assimilation processes. The final objective is to provide a quantitative assessment of the achievement of the first three objectives. We propose to have scientists use the tools and workstations to conduct research and create new materials for science, education, and public information from NASA/JPL image archive data. Scientific tools will be developed to meet the needs of scientists working on the 'Planetary Astronomy program, Solar System Visualization Scientific Analysis of NASA/JPL Image Archives' task (which is currently funded by code SL under RTOP 196-41-71). The science team has already defined a set of requirements for scientific analysis, visualization, and data assimilation tools. The tools described in the research and technology resumes are designed to meet these requirements. Tools will be developed to aid scientists in examining, organizing, and presenting variable-resolution images of surface and atmospheres. Emphasis will be placed on the tools required to produce visualizations of the data.

W91-70404 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 operate at Goddard Space Flight Center (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 (1) administer, coordinate, and manage the award of grants to participating universities; (2) negotiate appointments of industrial and government associates to CESDIS; (3) conduct periodic peer reviews of CESDIS by the USRA Council; and (4) act as the interface between NASA and CESDIS.

W91-70405 656-65-21

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

KNOWLEDGE-BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES

T. H. Handley 818-354-7009

The objectives for FY-91 are to design and develop the DataHub along with the initial data sets for a DataHub/LinkWinds-based system. The DataHub will also provide an environment for supporting development demonstrations and testing by implementing dummy servers for each of the other domains; i.e., software that provides data and interactions. This phase will establish the working interface between LinkWinds and the DataHub. The demonstration will use the data sets as determined by the science co-investigator.

W91-70406 656-65-22

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

GEOGRAPHICAL INFORMATION SYSTEM FOR FUSION AND ANALYSIS OF HIGH-RESOLUTION REMOTE SENSING AND GROUND TRUTH DATA

A. Freeman 818-354-1887

We will combine high-resolution remote sensing data with ground truth measurements and radar image models in the context of a Geophysical Information System (GIS). The GIS will be integrated with an existing set of image/data analysis tools and visualization techniques. Then, via case studies of two forest sites, one boreal and one tropical we will investigate the correlation between ground truth, e.g., biomass and vegetation water content and the remotely sensed data, explore the optimum combinations of sensed data to study various aspects of forest ecology, e.g., change with temperature different species and the effects of rainfall. The data set and software tools also can be used to try to validate the radar models, which are based on ground data measurements.

W91-70407 656-65-23

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

A DISTRIBUTED SYSTEM FOR VISUALIZING AND ANALYZING MULTIVARIATE AND MULTIDISCIPLINARY DATA

A. S. Jacobson 818-354-8086

The objectives of this program are to apply the Linked Windows Interactive Data System (LinkWinds) in a complex environment containing many of the elements addressed by scientists working in multidisciplinary teams on very large and distributed data bases. The specific objectives of the proposed 3-year program are: (1) Develop visual data analysis tools and controls specific to at least two science disciplines, and demonstrate them in current research activities; (2) Adapt LinkWinds to X-Windows for execution in a network environment on different workstations, and demonstrate its ability to display and analyze data sets residing in several distributed data storage locations and computationally supported by remote computing facilities; and (3) Use the adapted LinkWinds to demonstrate cooperative and interactive televisualization and analysis of data by geographically separated science teams. The science teams will work with the development team to evolve two tools each for atmospheric research and geologic imaging spectrometer data. LinkWinds system design will be modified to enable port to X-Windows. A toolkit (likely Motif) will be selected and the port begun through a joint effort with San Diego Supercomputer.

W91-70408 656-65-24

Ames Research Center, Moffett Field, CA.

CONSTRUCTION OF AN ADVANCED SOFTWARE TOOL FOR PLANETARY ATMOSPHERIC MODELING

R. M. Keller 415-604-3388

Investigative strategy involves developing the software tool in close coordination with planetary scientists at NASA Ames. The objective is to develop a scientist-usable version of this tool as swiftly as possible so as to obtain necessary feedback from users. In somewhat longer terms, the plan is to test the generality of the tool by experimenting with scientific models from other disciplines, such as earth sciences. We developed an initial prototype of the tool and used it to reconstruct a small portion of an existing model of Titan's atmosphere. We performed several small experiments using the modeling tool. We plan to extend the tool and evaluate its efficacy. In terms of extensions, we will add the capability of interfacing with pre-existing Fortran modules and will strengthen existing facilities for modifying models. With the help of atmospheric scientists, we will exercise the extended version of the system to test its limits and guide future improvements. Based on the results of this evaluation, we may continue using the tool and further increase the coverage of the Titan atmospheric model, or we may decide to redesign the tool to better meet scientists' needs and the objectives. In the latter case, we will likely reimplement the tool using new, more portable, software and hardware platforms.

W91-70409
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 656-65-25
MULTI-CHANNEL HOLOGRAPHIC BIFURCATIVE NEURAL NETWORK SYSTEM FOR REAL-TIME ADAPTIVE EOS DATA ANALYSIS
Hua Kuang Liu 818-354-8935

The proposed neural network architecture, referred to as 'OARS', for Optical Adaptive Resonant System, is based on principles similar to the adaptive resonance theory and utilizes currently available spatial light modulator technology, together with holographic and photorefractive material devices. The OARS can make optical data array comparisons, and relies upon principles basic to optical correlation architectures. The OARS, however, displays the higher level capability of optically multiplexing each input and comparing this input with many different reference matrices, creating an oscillatory optical resonance mode. The long range objective of the proposed work is to produce an OARS. The work is divided into three phases. During the first phase, the underlying behavior of the OARS including the data throughput capacity and cross-correlation interference are studied via theoretical analysis and experimental test. The Phase 2 work is to investigate hardware implementation for breadboard demonstration. The third phase is to see how the system can be used for Eos data analysis and other applications. In summary, the Jet Propulsion Laboratory will, for a period of 3 years, work on the following tasks: Task 1. Algorithm Investigation; Task 2. Experimental Evaluation of Optical and Opto-electronic Hardware: Task 3. Subsystem Testing and System Integration; and Task 4. Analysis of the Experimental Results.

W91-70410
Goddard Space Flight Center, Greenbelt, MD. 656-65-26
A SPATIAL ANALYSIS AND MODELING SYSTEM FOR ENVIRONMENTAL MANAGEMENT
Charles H. Vermillion 301-286-5111

This is a proposal to develop a uniform global environmental data gathering and distribution system to support the calibration and validation of remotely sensed data. Spatial Analysis and Modeling System (SAMS) is based on an enhanced version of the Federal Emergency Management Administration (FEMA) Integrated Emergency Management Information System and the DoD Air Land Battlefield Environment Software Systems. This system consists of state-of-the-art graphics and visualization techniques, simulations models, database management, and expert systems for conducting environmental and disaster preparedness studies. This software package will be integrated into various LANDSAT and UNEP-GRID stations which are planned to become direct readout stations during the Eos timeframe. This system would be implemented as a pilot program to support the Tropical Rain Measuring Mission (TRMM). This will be a joint NASA-FEMA-University-Industry project.

W91-70411
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 656-74-03
CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS
J. E. Solomon 818-354-2722
(656-65-04; 656-65-05)

The major objective of this task is the extension of concurrent processing testbed technology to an integrated science analysis environment. The three major elements of this objective are (1) development and demonstration of integrated science analysis and visualization tools, (2) development and demonstration of a data/information management system for a distributed computing environment, and (3) development of techniques and utilities for heterogeneous distributed computing resources to support computationally intensive science analysis activities. The approach to meeting these RTOP objectives draws heavily on the experience gained over the past two years in development and implementation of the concurrent processing testbed and its software environment, the Concurrent Image Processing Executive (CIPE). In addition, the experience and insight gained in applying this technology to real-time science information extraction during the recent Voyager Neptune encounter will be applied to the development of a science analysis testbed capable of handling the volume and complexity of data represented by both Earth Observing System (EoS) and future planetary exploration mission instrumentation. Focus for the development and demonstration of science analysis capabilities in a distributed computing environment will be provided by specific problems in planetary atmospheric dynamics analysis and visualization. This problem domain provides a full range of relevant challenges for integration of data management, analysis, and visualization utilizing concurrent computation technology.

Mission Operations and Data Analysis

W91-70412
Jet Propulsion Lab., California Inst. of Tech., Pasadena. 665-31-00
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 Spaceborne Imaging Radar-C (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

W91-70413
Goddard Space Flight Center, Greenbelt, MD. 669-30-10
SEARCH AND RESCUE ADVANCED TECHNIQUES
W. A. Hembree 301-286-8332

The objective of this RTOP is to apply aerospace technology to the support of the search and rescue community, beyond the now-operational COSPAS-SARSAT system. In particular, the goals are to: (1) enhance the future effectiveness and scope of the COSPAS-SARSAT system; (2) develop near-instantaneous distress alerting and location capabilities using geosynchronous satellites; and (3) develop means for applying remote sensing and satellite communications technology in aiding disaster mitigation and recovery. The following approaches will be utilized: (1) develop improved receiver-processor design with decreased susceptibility to interference; (2) develop and demonstrate prototype low-cost beacons; (3) define dedicated search and rescue satellite; (4) complete development and implementation of the Geostationary Operational Environmental Satellite (GOES) Search and Rescue ground station; (5) determine feasibility of placing an RF interferometer on a future GOES for locating 406 MHz beacons; and (6) identify means of realizing improvements in disaster damage assesment and critical communications by applying airborne remote sensing and satellite communications technology.

Space Processing Science and Spacelab Payload Development

W91-70414
Lewis Research Center, Cleveland, OH. 674-21-05

ELECTRONIC MATERIALS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The plan for FY-91 of this task is to continue an in-house cooperative project with Westinghouse Research Laboratories and to manage a contract with Westinghouse to study the growth kinetics of physical vapor transport 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.

674-21-06

W91-70415
Langley Research Center, Hampton, VA.
ELECTRONIC MATERIALS
A. L. Fripp 804-864-1503

The objective of this research grant is to develop techniques for vapor phase crystal growth in space. The approach is to develop safe, low-pressure vapor sources for epitaxial growth of crystal films.

674-21-08

W91-70416
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.

674-22-05

W91-70417
Lewis Research Center, Cleveland, OH.
COMBUSTION SCIENCE
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 obtain an understanding of the fundamental combustion phenomena for which low gravity analysis and experimentation can be of use in: (1) isolating the gravity related mechanisms (e.g., buoyant convection); (2) determining the influence of transport phenomena normally obscured by gravitational effects (e.g., thermophoresis, thermocapillarity, simple mass and thermal diffusion); (3) creating desired symmetries and/or boundary and initial conditions (e.g., spherical droplets, negligible sedimentation); and (4) improving in-space system performance, principally spacecraft fire safety.

674-23-01

W91-70418
Lyndon B. Johnson Space Center, Houston, TX.
BIOTECHNOLOGY RESEARCH
Clarence F. Sams 713-483-7160

This research is focused on the development of science in support of the NASA Biotechnology Program. The projects within the RTOP will have five general objectives: (1) to gain a better understanding of basic cell science questions of importance to current biotechnology which have apparent gravity induced limitations or can be better studied in the microgravity environment; (2) to study unique bioprocess limitations caused by gravity dependent phenomena and determine the potential for improvement during biological processing in microgravity; (3) to develop methodology and procedures for accomplishing biotechnology investigations in microgravity; (4) to explore new research applications of biological target materials and new technology innovations; and (5) to define and develop analytical methods and requirements for biotechnology research facilities planned for the U.S. Space Station. This RTOP is designed to serve as a basic science resource in support of NASA biotechnology. Research will be performed both in-house at Johnson Space Center (JSC) and at associated universities, research centers, and institutions. JSC will perform independent research and serve as a point of contact for the extramural investigators. JSC will participate in the analysis of results, promote scientific communication, and aid the investigators in the development of NASA relevant research efforts. Scientific data resulting from these studies will be used to formulate new proposal for flight experiments, promote ground-based applications of these technologies, and refine the scientific background and justifications for proposed flight experiments.

674-23-08

W91-70419
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.

674-24-02

W91-70420
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. It also offers an abundance of critical points which are generally well studied theoretically.

W91-70421
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **674-24-04**
FLUID DYNAMICS AND TRANSPORT PHENOMENA
D. Strayer 818-354-1668

The Fluid Dynamics and Transport Phenomena RTOP consists of two tasks: the Coherence Length Task and the Low Temperature Experiments for Microgravity Task. The objective of the Coherence Length Task 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 principle objective of the Low Temperature Experiments for Microgravity Task is to begin the development of ideas for low temperature research in the microgravity environment of space. Specific objectives are (1) to perform measurements of the attenuation of third sound in superfluid helium films to demonstrate the potential for applying third sound to microgravity measurements; and (2) to design a low temperature apparatus to levitate and control a drop of liquid helium so the superfluid can be studied isolated from all solid boundaries.

W91-70422
Lewis Research Center, Cleveland, OH. **674-24-05**
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 are 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 Lewis Res. Ctr. 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.

W91-70423
Marshall Space Flight Center, Huntsville, AL. **674-24-08**
FLUID DYNAMICS AND TRANSPORT PHENOMENA
Donald O. Frazier 205-544-7825

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. For low-gravity experiments, quantitative comparisons between measured fluid velocity fields and those calculated by developed multi-dimensional fluid dynamic and heat transfer codes require appropriate measurements of residual acceleration fields. The approaches are to: (1) develop numerical models for fluid flow and transport phenomena in order to elucidate and predict the sensitivity of experiments involving fluid and transport phenomena to low-gravity fields; (2) develop efficient methods of analyzing the acceleration data relative to the various experiments; and (3) coordinate planned acceleration measurements on International Microgravity Laboratory-1 (IML-1) to assure that experimental demands are met.

W91-70424
Jet Propulsion Lab., California Inst. of Tech., Pasadena. **674-25-04**
METALS AND ALLOYS
Eugene H. Trinh 818-354-7125

The Metals and Alloys Research and Technology Operating Plan consists of three tasks. 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 dielectrophoretic forces. Experimental and theoretical investigations involved in this task are (1) the study of physical and chemical principles involved in the development of electrostatic levitation; (2) the development of sample levitation and manipulation capabilities in the environments of wide range temperature and pressure; (3) the study of charged drop dynamics using liquids and melts; and (4) the measurement of thermophysical properties of various materials. 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 electromagnetic levitation techniques using gaseous and liquid hosts and non-invasive measurement methods. The Acoustic Containerless Science Task objective is to apply single mode acoustic levitation concepts developed in the previous Multimode Acoustic Research RTOP to study the containerless processing of glasses and ceramics using microwave heating techniques. The task objectives will include (1) determination of the reaction mechanism, microstructure development and physical properties associated with containerless microwave synthesis of ceramics; (2) development and application of noncontact microwave techniques for monitoring the energy absorption during processing and also measuring thermophysical properties of containerlessly positioned samples; and (3) theoretical modeling of the acoustic and microwave field effects on glass and ceramic processing.

W91-70425
Lewis Research Center, Cleveland, OH. **674-25-05**
METALS AND ALLOYS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of the Metals and Alloys RTOP 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 dentritic 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.

W91-70426
Marshall Space Flight Center, Huntsville, AL. **674-25-08**
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 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.

674-26-04

W91-70427
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLASS RESEARCH - GLASS FORMING ABILITY AND CRYSTALLIZATION OF GLASS
Eugene H. Trinh 818-354-7125

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.

674-26-05

W91-70428
Lewis Research Center, Cleveland, OH.
GLASSES AND CERAMICS
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of this RTOP is to identify and initiate fundamental research in the areas of glasses and ceramics wherein microgravity related phenomena play an important role. Phase immiscibility in glasses has been initiated as an in-house research effort and an Announcement of Opportunity (AO) proposal was submitted. Research involving glass foaming, order-disorder transitions of ceramic slips and agglomeration of ceramic powders is under way at universities. A follow-on proposal to the initial efforts in foam formation and destruction has defined drop tower experiments. Ceramic powder agglomeration research has been tied in with laser light scattering development in the Microgravity Materials Science Lab. (MMSL). A new effort in fiber growth has been initiated via a National Research Council (NRC) fellow. This latter effort has now transmitted to Office of Aeronautics, Exploration, and Technology (OAET).

674-27-05

W91-70429
Lewis Research Center, Cleveland, OH.
MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL)
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

The objective of the MMSL RTOP 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, mechanical engineering, and physics. Specialized equipment in the MMSL include an electromagnetic levitator, the bulk undercooling apparatus, a vacuum welding chamber, the Diffusive Mixing of Organic Solutions (DMOS) emulator, a number of electro-optic materials Bridgman furnaces, the isothermal dentritic 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.

674-28-05

W91-70430
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 activities funded under this RTOP is to provide the manpower, equipment, and facility support necessary to perform reduced gravity experiments in the Lewis Res. Ctr. (LeRC) 2.2 Second Drop Tower, Zero-Gravity Facility, Learjet, and supporting laboratories. Experiments are conducted to support both principal investigator studies and LeRC in-house studies primarily in fluids and combustion science. Funding is utilized for aircraft flight hour charges, composite rate charges for operations engineering support via a support service contract, engineering design through a university (Case Western Reserve) cooperative agreement, and a variety of facility support hardware, components, and instrumentation.

674-28-08

W91-70431
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.

674-29-04

W91-70432
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. Detailees 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.

674-29-05

W91-70433
Lewis Research Center, Cleveland, OH.
CONSULTING AND PROGRAM SUPPORT
Richard J. Parker 216-433-2871
(694-22-00; 694-23-00; 694-03-03; 694-24-00)

This activity provides for the management and coordination of the Lewis Res. Ctr. (LeRC) Microgravity Science and Applications program. The LeRC Space Experiments Division and Materials Division are responsible for most of the activities covered under the related RTOPs. Funded under this task are program management and reporting activities and the LeRC Program

Support charges which include facility usage, computer usage, and instrument pool usage.

W91-70434

Marshall Space Flight Center, Huntsville, AL. **674-29-08**

CONSULTING AND PROGRAM SUPPORT

B. G. Bass 205-544-7756

The objectives of this RTOP are (1) to provide the necessary scientific manpower to augment the implementation of the Microgravity Science and Applications (MSA) research and technology development effort; and (2) to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purposes of making them aware of the research opportunities offered by the MSA program; stimulating their interest and active involvement in the program; gauging their response to the scientific results being obtained by the program; identifying research areas in which the program should concentrate; initiating in-house research activities in selected topics pertinent to the MSA program; and evaluating the ongoing research effort. MSFC will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through working groups, seminars and workshops, science reviews, and a visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented and this documentation will be included in the NASA Headquarters data base for access to the scientific community, NASA Headquarters Microgravity Science and Applications Division, and other NASA centers.

OFFICE OF SPACE OPERATIONS

Advanced Systems

W91-70435

Goddard Space Flight Center, Greenbelt, MD. **310-10-23**

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 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.

W91-70436

Goddard Space Flight Center, Greenbelt, MD. **310-10-26**

FLIGHT DYNAMICS TECHNOLOGY

Ken Galal 301-286-9216

The objectives of this RTOP are to develop, evaluate, and demonstrate new technology for flight dynamics in the Tracking and Data Relay Satellite System (TDRSS), Space Transportation System (STS), and Space Station Freedom (SSF) era, encompassing algorithms, techniques, software, and hardware for attitude and orbit determination, prediction, and analysis for both ground-based and onboard applications. 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. Research efforts will be divided into two tasks covering attitude and orbit studies. Experience gained in each research area will be shared so that each task may take advantage of any advancements that may have a parallel application. Task 1, Advanced Attitude Determination, will study and develop advanced, generic attitude determination methods. Task 2, Advanced Orbit Determination, will study and develop advanced orbit determination methods.

W91-70437

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **310-10-60**

ASTROMETRIC TECHNOLOGY DEVELOPMENT

J. Ulvestad 818-354-6734

(310-10-61; 310-10-62; 310-10-63; 310-20-67; 310-30-69; 310-30-70)

The objective of this RTOP is to design and demonstrate improved techniques of astrometric data acquisition and analysis as used by the Deep Space Network (DSN) to support navigation. Central to this goal is quantifying and reducing the limiting error sources for various radio and optical tracking data types. Starting from an understanding of the underlying physics, potential error sources are studied to determine their impact on the final navigation observables. Deep-space tracking is limited by uncertainties in the angular components of spacecraft position and velocity. Thus a major thrust is the refinement of methods of angular spacecraft navigation using various astrometric techniques, primarily Very Long Baseline Interferometry (VLBI). Current efforts focus on atmospheric propagation effects, errors caused by radio-source structure, and optimal observing strategies for differential spacecraft-quasar navigation. In the next several years, demonstrations of differential angular measurements with accuracies approaching 1 nanoradian will be made on Magellan and Galileo, with the aim of achieving such accuracy routinely by the late 1990's. To advance the capability for target-relative navigation, improvement of the tie between the planetary ephemeris and the radio reference frame is being pursued using several methods. Connected element interferometry (CEI) could provide more efficient and reliable medium-accuracy (50 to 100 nrad) navigation using baselines of 10 to 100 km in length. Testing of a realtime CEI correlator system at Goldstone, and demonstrations on both the Magellan and Galileo spacecraft in the next year, will verify the design and accuracy of this system. Evaluation of optical tracking techniques will determine their potential for application on future laser-equipped spacecraft. Both filled-aperture and interferometric devices are being considered, with the instruments and errors being studied as in the early days of astrometric VLBI. The current focus is on data and error analysis for filled-aperture telescopes. Problems associated with creation of a stable optical reference frame also are being addressed.

W91-70438

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **310-10-61**

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. These calibrations will include: (1) sub-cm zenith tropospheric delay estimates; (2) cm-level monitoring of earth orientation with resolution of better than one day; (3) sub-nanosec DSN intersite clock synchronization; and (4) several-cm geocentric determination of DSN radio antenna coordinates through site ties with collocated GPS receivers. These GPS-based media, clock, earth orientation, and station location parameters, which will support precise tracking during future deep space missions, are estimated simultaneously with high-accuracy (sub-meter) GPS orbits on a continuous basis. GPS calibrations can provide the DSN with a medium accuracy (50 nanoradian) tracking capability using spacecraft tones, without the need to move the radio antennas off the spacecraft to acquire quasar data. GPS-based earth orientation calibrations can reduce by about a factor of four the amount of DSN antenna time presently required to do quasar-based Very Long Baseline Interferometry (VLBI) earth orientation measurements. These capabilities will increase the percentage of DSN antenna time dedicated to direct spacecraft tracking, ultimately leading to potentially greater science returns and more efficient use of DSN resources. For high-precision (sub-50 nanoradian) missions where differential spacecraft-quasar VLBI is necessary, the GPS-based calibrations will enhance tracking accuracy by contributing calibrations of tropospheric delays and earth orientation timed to coincide with the deep space radio tracking passes. GPS techniques 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 for satellites carrying advanced GPS flight receivers. NASA has announced its intention to provide tracking support for several international missions of this type, such as the Japanese VLBI Space Observatory Program (VSOP). The 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 earth orbiters.

310-10-62

W91-70439
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; 310-20-66)

The objective of this RTOP is to develop and demonstrate the technology of precise frequency and timing for Deep Space Network (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 1991. 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 late 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 (DSS). This effort will provide near real time information on the status of the stability of precise frequencies generated, distributed, and used throughout a DSS.

310-10-63

W91-70440
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE SYSTEMS AND NAVIGATION TECHNOLOGY
Lincoln J. Wood 818-354-3137
(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 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 NASA (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 operation's costs by increasing the efficiency and reliability of radio metric data processing. The development and demonstration of portable graphical user interfaces designed to improve user productivity by conveying essential information in concise graphical form is underway. Other areas of development include potential navigation applications of expert system technology and automated navigation operations.

310-20-33

W91-70441
Goddard Space Flight Center, Greenbelt, MD.
NETWORK 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 potential for use of RF to IF fiber optic technology in future ground station applications. The extremely wide bandwidth and low loss available in fiber optic cables makes this technology an attractive alternative to coaxial cable and waveguide. The task will concentrate on the feasibility of transmitting RF signals using fiber optics. In more conventional fiber optic applications, digital signals are transmitted using the electroptic components as switched devices whereas this experiment will utilize these devices in a linear mode. Another major goal is to investigate new modulation and coding techniques for the TDRSS K-Band channel. The increasing use of satellite communications in conjunction with growing user sophistication has imposed, and will continue to impose, the requirement to support increasingly higher data rates and data throughput. Implementation for data rates of 300 Mbps and higher will be studied and prototyped, as applicable.

310-20-34

W91-70442
Goddard Space Flight Center, Greenbelt, MD.
SYSTEMS ENGINEERING TECHNOLOGY FOR NETWORKS
Keiji K. Tasaki 301-286-8871

The objective of this RTOP is to conduct research into methods and techniques with which emerging systems engineering technologies potentially applicable to the ground segment of the Space Network (SN) could be evaluated. Currently there exists no formal method of evaluating new concepts, algorithms, software packages, and hardware components which may potentially be beneficial to the SN ground segment facilities, including the Network Control Center (NCC), the White Sands Ground Terminal (WSGT), etc. Under this RTOP, structured and formalized methods and techniques, which will enable us to evaluate quantitatively the effectiveness of emerging technologies, will be investigated. The impact of introducing a new component into these facilities could then be determined using such formal methods. In addition, the subject of SN resource scheduling will also be investigated. As the number of SN users increases over the next 10 years, the effective use of the SN resources becomes crucial. This part of the RTOP will examine, not only the scheduling techniques which have been analyzed within the NCC environment, but also the existing operational systems in the DOD and commercial sectors. The result of this investigation will be a recommended approach to SN resource scheduling, including generic scheduling.

W91-70443

Goddard Space Flight Center, Greenbelt, MD. **310-20-38**

NETWORKS COMMUNICATIONS TECHNOLOGY

T. E. Butler 301-286-7335

The objectives of this RTOP are (1) to establish an Open Systems Interconnections (OSI) testbed to investigate techniques for interfacing with OSI networks; (2) to investigate Wide Area Networks (WAN) technology that can support packet switching at high rates; and (3) to expand the functionality of the Virtual Channel Sorter Multiplexer (VCSM) prototype to include a rudimentary gateway function for Consultative Committee for Space Data Systems (CCSDS) to OSI protocol conversion. The objectives are being pursued under three tasks. The first task involves analyzing and assessing the relative merits of OSI network technology for application in NASA communication networks. The second task is the study and procurement of a three node WAN that can support packet switching rates of 150 Mbps for use in a testbed. The third task is being pursued via a work direction to procure hardware and develop software that can perform the routing of CCSDS protocols via OSI protocols. 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 Research and Development funds.

W91-70444

Goddard Space Flight Center, Greenbelt, MD. **310-20-39**

ADVANCED TRACKING TECHNOLOGY

Harley J. Mann 301-286-4343

The objectives of this RTOP are to design, develop, and demonstrate Advanced Tracking and Data Relay Satellite (ATDRS) era tracking systems which provide for 25-meter tracking accuracy. It is desired that these systems place no load on Tracking and Data Relay Satellite System (TDRSS) user services, use only continental United States ground stations, provide for rapid ATDRS post maneuver trajectory recovery, and potentially be shared with the user navigation system. A two phase approach will be used. 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 Advanced Tracking and Data Relay Satellite System (ATDRSS) program as well as stimulate future advanced work in the advanced tracking area if warranted.

W91-70445

Goddard Space Flight Center, Greenbelt, MD. **310-20-46**

ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS

R. P. Hockensmith 301-286-9067

The objective of the work under this RTOP is to achieve technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems, and 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 operational and evolving data relay satellite systems, 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 and low cost within the required procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

W91-70446

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **310-20-64**

ADVANCED TRANSMITTER SYSTEM DEVELOPMENT

Rob Hartop 818-354-3433

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. 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 with expert systems. The resulting transmitter technology will be applicable to many NASA anticipated requirements including support for future robotic and manned missions to the Moon and Mars. Techniques will be developed for combining multiple high power sources while receiving multiple frequencies in an efficient and versatile manner, including beam waveguide environments. Advanced dichroic plates of new design are being developed for frequency separation and simultaneous operation, including up- and down-links in the same and different frequency bands. This RTOP also provides Ka-band systems analysis to define ground systems support requirements including support for the Ka-Band Link Experiment (KABLE) using the Mars Observer Spacecraft with the new Research and Development antenna at Deep Space Station (DSS) 13.

W91-70447

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **310-20-65**

ANTENNA SYSTEM DEVELOPMENT

Alan Cha 818-354-3509

(310-20-64; 310-20-69; 310-20-70)

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 Deep Space Station (DSS) 13 antenna Present objectives are to: (1) develop multiple frequency-band communications capabilities at DSS 13 to cover 1 to 45 GHz including simultaneous dual-frequency and uplink/downlink operations; (2) achieve high accuracy and stable radio frequency (RF) beam pointing at 32 GHz; and (3) extend BWG antenna technology to the 70 m and existing 34 m antennas. To achieve these objectives, accurate computer analysis software appropriate to large high-frequency reflectors is used. Demonstrations and tests are planned to verify analytical models and understand critical areas needing cost-effective improvement. The goal is to provide technology and to enable informed decisions on when and how to deploy Ka-band Deep Space Network (DSN) mission support.

W91-70448

Jet Propulsion Lab., California Inst. of Tech., Pasadena. **310-20-66**

RADIO SYSTEMS DEVELOPMENT

J. Bautista 818-354-6994

(310-30-65; 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 telemetry and radio navigation during deep space missions. The improvements sought are increased performance, reduced implementation costs, and increased reliability of receiving equipment and cryogenic systems. These improvements address future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications down link is the gain of the receiving antenna divided by the system noise temperature (G/T). This RTOP addresses the value of keeping 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 (MASER's) and high-electron mobility transistors (HEMT's) 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. There is also a continuing effort to develop a 1.5 K cooling system appropriate for use on antennas with beam waveguide feed systems to greatly improve MASER performance and cryogenic reliability. In addition, there is a new effort to demonstrate fiber optic technology to improve and increase the station's signal transport capabilities.

W91-70449 **310-20-67**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT
Marc D. Rayman 818-354-2544
(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 missions of the future supported by the Deep Space Network (DSN). 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. 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 conceptual design and planning stages, so that other appropriate sources of funding can be identified for the execution of the flight demonstrations. 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. Studies indicate, however, 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 Research and Development facility, formulation and validation of an atmospheric weather model based on existing satellite-collected data, and establishment of a network of three autonomous atmospheric visibility monitoring (AVM) telescopes.

W91-70450 **310-30-69**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSS 13 INSTRUMENTATION AND CAPABILITIES
M. Gatti 818-354-2123
(310-10-60; 310-10-62; 310-20-64; 310-20-65; 310-20-66; 310-30-70; 310-30-73)

The objective of this RTOP is to provide the Deep Space Station (DSS) 13 facility at Goldstone with the basic capabilities required to support the activities planned in related RTOP's of the Advanced Systems Program. The majority of these activities involve 32 GHz technology development and demonstrations of the new beam waveguide antenna at DSS 13. The basic capabilities, referred to as core capabilities, are determined based on the needs of the users of the station. Further core capabilities are to be implemented in a timely manner consistent with the future goals of the Advanced Systems Program. The immediate capabilities that must be satisfied are dictated by the Mars Observer Ka-Band Link Experiment (KABLE) and the plan to decommission the existing 26-meter antenna. These capabilities include dual X/Ka-band receive strings, dual S/X-band receive strings, precision pointing, and monitor and control. The X/Ka-band string consists of X-band MASERs, Ka-band high electron mobility transistors (HEMT's), phase lockable downconverters, and digital telemetry processors. Part of the core capability of the facility involves establishment of a performance baseline in terms of G/T (antenna gain divided by the total system temperature) for all frequencies employed on the new antenna. A work unit is dedicated to developing highly accurate techniques to do this calibration at 32 GHz, which is a new frequency for the Deep Space Network (DSN). Another work unit will supply water vapor radiometers to be used by experimenters in a variety of applications including vernier pointing, and to provide atmospheric corrections to data. Certain capabilities of interest only to single users will be provided by those users. At the end of this type of program, an agreement may be reached whereby that capability is absorbed into the core facility of DSS 13 and support for the capability is continued.

W91-70451 **310-30-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NETWORK SIGNAL PROCESSING
E. Satorius 818-354-3016
(310-30-65; 310-30-66; 310-30-69; 310-30-72)

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 current and future performance requirements with improved reliability, maintainability and operability. Key objectives for this RTOP are to: (1) 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; (2) develop techniques for generating array feed error signals to provide electronic antenna pointing capability at Ka-band thereby recovering up to 3 dB in antenna pointing losses; (3) improve telemetry signal-to-noise ratio (SNR) performance relative to existing DSN systems by 1 dB to 3 dB; (4) develop carrier arraying techniques to improve carrier acquisition threshold by 1 dB to 3 dB relative to existing single-station DSN systems; (5) demonstrate 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. During FY-91 the main tasks are to: (1) conduct a proof-of-concept field demonstration of a Ka-band array feed signal processing system; (2) demonstrate binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK) telemetry data extraction as well as BPSK suppressed carrier acquisition for a 15 MHz bandwidth advanced receiver; (3) demonstrate two-station carrier arraying at the Goldstone DSN complex; (4) demonstrate a 40 MHz bandwidth, 2 megachannel digital spectrum analyzer; (5) perform final fabrication of a high speed sampling and digitizer microcircuit implemented with gallium arsenide (GaAs) technology; and (6) perform design and layout of a wideband, high resolution digital frequency synthesizer microcircuit with applications to both the Goldstone Solar System Radar and the Block 5 receiver.

W91-70452 **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 Deep Space Network (DSN) supported missions for the new century. We focus on improving space communication capability at low cost, for example, by increasing bit rate for given received signal power.

The work planned will involve five areas. Coding/decoding (source and error-correcting) and modulation/demodulation techniques for the future will be investigated and demonstrated. Initially, a coding experiment on Galileo will demonstrate a coding gain of more than 1 dB over the original Galileo code. The longer-term goal involves new research into channel codes and source codes. 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. Coding ideas developed and/or analyzed in this RTOP will be demonstrated. Support for the demonstration of the Big Viterbi Decoder will become part of this RTOP after a successful 1991 Galileo demonstration and the implementation handoff review. The June Review Book will be produced in paper copy and in electronic form.

W91-70453 **310-30-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VITERBI DECODER DEVELOPMENT
J. 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 Deep Space Network (DSN) by up to 2 dB. The resulting coding gain is relatively low cost and complements alternative approaches to link performance improvement such as increasing antenna size, arraying antennas, and increasing the power transmitted from the spacecraft. The approach is to build a prototype Big Viterbi decoder, denoted BVD, and test with Galileo in May 1991. In this experiment, Galileo will transmit data encoded with a (15, 1/4) convolutional encoder at rates of 134.4 Kbit/s and 115.2 Kbit/s. The BVD will decode the received symbol stream in real-time. Following successful completion of this demo, the BVD will be produced under Implementation Program in time for Galileo's 1995 Jupiter encounters. Use of the BVD design for the main Galileo mission will improve link margin by estimated 1.3 dB compared to (7, 1/2) codes. It will enable 30 percent increase in overall science data return, 100 percent increase in science return during Jupiter encounter, and substantial reduction in need for antenna arraying during subsequent Jupiter moons encounters. The BVD will be flexible enough to be used for similar experiments with other deep space missions, including existing probes such as Voyager, because it is designed as a fully programmable unit. Hence any convolutional code with constraint length of up to 15 and code rate of 1/n, n = 2...6, can be applied. During FY-91 the main tasks are (1) complete BVD integration; (2) perform testing in laboratory and Compatibility Test Area (CTA) 21; (3) plan and conduct in-flight test at Goldstone; and (4) conduct handover to DSN Implementation Program.

W91-70454 **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 recent advances in human factors analysis, data and information base management, semantic modelling, 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 quantify 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 Tracking and Data Relay Satellite System (TDRSS) operations, mission operations, mission support computing, and general systems engineering activities.

W91-70455 **310-40-45**
Goddard Space Flight Center, Greenbelt, MD.
MISSION OPERATIONS TECHNOLOGY
Henry L. Murray 301-286-6149

The advent of powerful engineering workstations has greatly increased the scope of spacecraft control center systems. Techniques for increasing the efficiency, reliability and fault tolerance of manned systems involve a number of interrelated disciplines such as man-machine interfaces, artificial intelligence (AI), data base engineering, simulations, and software reuseability. The architecture for control center systems is evolving to workstation based technology. Benefits to mission operations using this technology include enhanced user interfaces, system expansion capability, and physical portability. The objective of this RTOP is to develop techniques and validate concepts that will improve spacecraft control center operations efficiency and reliability, and reduce mission operations costs. The intent of this effort is to apply and evaluate the latest computer graphics technologies, automation technologies, and man-machine interfaces to specific workstation environments for control center operations.

W91-70456 **310-40-47**
Goddard Space Flight Center, Greenbelt, MD.
EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS
Walt Truszkowski 301-286-8821

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.

W91-70457 **310-40-48**
Goddard Space Flight Center, Greenbelt, MD.
DATA STORAGE TECHNOLOGY
Ward Horner 301-286-5804

The objective of this RTOP is to develop systems technology and evaluate storage components to provide high performance, low life cycle cost data storage systems to meet data capture, buffering, processing, and distribution requirements for future space missions. Commercial tape and disk subsystems have evolved functional, performance, and cost characteristics which now make them candidates in the development of high performance, cost effective mass storage systems. These systems will require distribution of data over multiple drives with appropriate failure mode control to ensure data integrity. NASA-specific very large scale integration (VLSI) controllers for management of spacecraft telemetry processing and flow will be developed for use with commercial parallel disk controllers, disk drives, and standard interfaces. These elements will be used to prototype advanced data storage system architectures adaptable to a range of mission data rates. These systems will then be integrated with prototype

VLSI telemetry handling systems being developed for the Data Interface Facility (DIF) and Enhanced Packet Processor to perform higher level telemetry processing and routing functions.

W91-70458 310-40-49

Goddard Space Flight Center, Greenbelt, MD.

ADVANCED ENVIRONMENTS FOR SOFTWARE AND SYSTEM DEVELOPMENT

Sylvia B. Sheppard 301-286-5049

The objective of this RTOP is to develop and evaluate systems-level concepts and technologies that will be utilized to optimize the management, development, operation, and evolution of Mission Operations and Data Systems Directorate (MO&DSD) data systems. Major subobjectives are (1) the development of a state-of-the-art performance modeling environment consisting of an integrated set of tools and support services to facilitate all phases of the use and reuse of data system modeling and analysis; and (2) the definition and phased prototyping of an advanced software engineering environment. The RTOP approach is to develop or acquire associated tools and techniques, apply the tools and 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 Tracking and Data Relay Satellite Systems (TDRSS) operations.

W91-70459 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.

W91-70460 310-40-73

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

DSN DATA PROCESSING AND PRODUCTIVITY

L. Cooper 818-354-3252

(310-30-69)

The objective of this RTOP is to develop and demonstrate advanced information processing technologies to improve the capability of the Deep Space Network (DSN) to meet user needs, including: (1) reducing development costs and risk; (2) increasing the predictability, reliability, and efficiency of service; and (3) reducing the overall degree of difficulty to operate the DSN. The work units in this RTOP fall into two basic areas. The first area is Improvement to DSN Operational Capabilities. Advanced information processing technology can be applied to improve the way that the DSN currently operates. Work units in this category address the use of Open Systems Interconnect (OSI) standards for communications, automation of monitoring and control functions, and end-to-end data flow analysis. The second basic area is Software Management Technology. A growing fraction of the total cost to implement and maintain the DSN is attributable to software. The inability to reliably predict software development schedules jeopardizes mission support and translates into increased costs and reduced capability. One work unit in this RTOP will develop a method and tool, tailored to the DSN environment, for making reliable schedule estimates. A second work unit will develop a state-of-the-art software project simulation model which will allow DSN managers to assess and predict the resource and schedule outcomes associated with changing requirements, inserting new technology, changing budget or workforce levels, and varying the development paradigms.

OFFICE OF SPACE FLIGHT

Advanced Programs

W91-70461 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. The system is capable of performing in harsh environments and continuously compensating for dynamic conditions. It 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 multi-sensor network to test system performance and evaluate the system's effectiveness.

W91-70462 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 of ground processing of Space Transportation System (STS) and payload hardware. Advanced development of state-of-the-art technologies will be directed towards decreasing turnaround times, increasing overall efficiencies, and increasing quality and safety.

W91-70463 906-20-03

Lyndon B. Johnson Space Center, Houston, TX.

TELEMETRY AND COMMAND PROCESS APPLICATIONS LANGUAGE

Lorraine E. P. Rice 713-483-8477

The objective of this RTOP is to research and develop an interpreted, English-like language that can be used both as a programming language and as a user interface language which is specifically tailored to Mission Control Center needs. The reliability of this language during operations will be evaluated. A workstation tool utilizing the language will be developed to provide computation building and managing functions for ground support personnel.

W91-70464 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS ASCENT GUIDANCE DEVELOPMENT
Aldo Bordano 713-483-8177

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 requirement will be defined.

W91-70465 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT OF ADVANCED GRAPHICS LAB APPLICATIONS
Peter Galicki 713-483-8086

The objectives of this RTOP are (1) implementation of advanced graphics rapid prototyping functions, including graphical tree manipulation based on user defined conditions; (2) optimization of graphics operations to increase system performance; (3) a high-level engineering graphics library for non-graphics users; and (4) incorporation of advanced user interface capabilities. The approaches are (1) development of 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; and (2) development of graphics server/client software to be utilized within X-Window environment. This server will be ported to (Programmer's Hierarchical Interactive Graphics System) PHIGS/PHIGS+ resulting in a portable high-level graphics tool that can be applied to simulation and engineering analysis.

W91-70466 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
INTEGRATED AUTONOMOUS FLIGHT OPERATIONS FUNCTIONAL SIMULATION
Chris Culbert 713-483-8080

The objective of this task is to develop an integrated software testbed for mission analysis and design of autonomous space vehicles. This testbed, AUTOPS, will serve as an environment for the evaluation and development of hardware and software technology requirements and designs, identification of command and control approaches, performance tradeoffs between operational configurations, and a general assessment of the effective integration of automation technologies into autonomous vehicle operations. Specifically, this task will address the automation of on-orbit operations in such areas as trajectory control (e.g., rendezvous, proximity operations, traffic management, and collision avoidance), consistent with 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.

W91-70467 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
SPACE SHUTTLE MISSION OPERATIONS EFFECTIVENESS
T. A. Heindel 713-983-2639

The purpose of this RTOP is to immediately improve the effectiveness of Space Shuttle flight controllers by placing real time expert systems into mission control to perform estimated telemetry monitoring and subsystem fault diagnosis. Telemetry processors are currently installed in mission control and real time Space Shuttle telemetry data is being routed into expert systems which have been developed by flight controllers. Initial results of this RTOP demonstrated that the quality of flight decision making is substantially improved by the use of the expert systems to enhance the monitoring capabilities of flight controllers. Additionally, training time is reduced and a small manpower reduction is possible through the use of these systems. The systems are developed using standard techniques and commerically-available technologies such that they are portable among both existing and planned real time environments.

W91-70468 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED SOFTWARE DEVELOPMENT WORKSTATION
Ernest M. Fridge 713-483-8109

The primary purpose of this project is to investigate knowledge based techniques for software and information 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 the 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.

W91-70469 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.

W91-70470 906-21-03
Lyndon B. Johnson Space Center, Houston, TX.
DEVELOP ENVIRONMENT FOR 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 Johnson Space Center (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.

906-21-03

W91-70471
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS AND EXPERT SYSTEMS TO SPACEFLIGHT OPERATIONS
Ervin ONeal Grice 713-483-8082

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 Space Transportation System (STS) ground flight operations planning and replanning. The approach is to develop a reusable 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 COMPASS (Computer Aided Scheduling System) for planning and replanning; and to use this system as a platform for the continuing development of advanced scheduling technology in collaboration with the Jet Propulsion Laboratory and other NASA centers.

906-22-03

W91-70472
Lyndon B. Johnson Space Center, Houston, TX.
APPLICATION OF EXPERT SYSTEMS TO ON-BOARD 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. The 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.

906-30-03

W91-70473
Goddard Space Flight Center, Greenbelt, MD.
SATELLITE SERVICING
R. Rubilotta 301-286-2749
(906-32-02)

The objective of Goddard Space Flight Center (GSFC) advanced development activities is to provide a capability for on-orbit satellite servicing and to continue with extravehicular activity (EVA) servicing tools and facilities. The effort, however, is expanding from primarily Shuttle Orbiter based EVA servicing with new tasks focused on remote servicing of platforms such as Tropical Rain Measuring Mission (TRMM) and Earth Observing System (EOS). Supporting this expansion is the advanced development providers for design of manipulator operated tools and connectors and fabrication of protoflight configuration of the module service tool (MST) for manipulator operations, and development of a continuous wave laser range for remote servicing rendezvous and docking operations.

906-30-04

W91-70474
Lyndon B. Johnson Space Center, Houston, TX.
DEXTEROUS MANIPULATION DEMONSTRATION
L. G. Monford 713-283-5409

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). 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 the Johnson Space Center. A Conceptual Design Review was completed in November 1988; a Preliminary Design Review was completed in March 1989; and the Critical Design Review was completed December 1989. Flight hardware completion is scheduled for late FY-90.

906-30-04

W91-70475
Lyndon B. Johnson Space Center, Houston, TX.
OPTICAL COMMUNICATION THROUGH THE SHUTTLE WINDOW (OCTW) FLIGHT DEMONSTRATION
J. L. Grady 713-483-1464

The objectives are (1) to demonstrate the ability to transmit high rate digital data and video between the crew cabin and the payload bay on the Shuttle through an aft window without penetrating the pressure bulkhead; and (2) to measure the performance of a fiber optic system exposed to the space environment, key components of which have never before been used on the Shuttle. Flight hardware will consist of a box inside the crew cabin containing optical transmitters and receivers, which will be stimulated with test signals. Optical fiber will carry the test signals to one side of the window. Fiber optic cable in the payload bay on the other side of the window will receive the signals and carry them to an optical repeater. Via a similar route, the test signals will then return to the cabin where their performance will be measured and recorded.

906-30-04

W91-70476
Goddard Space Flight Center, Greenbelt, MD.
SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT)
Orlando Figueroa 301-286-8986

The Superfluid Helium On-Orbit Transfer (SHOOT) is a Space Transportation System (STS) based flight experiment designed to provide advanced technology for replenishing 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. It will also 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.

906-30-04

W91-70477
Lyndon B. Johnson Space Center, Houston, TX.
PLASMA MOTOR GENERATOR EXPERIMENT
J. E. McCoy 713-483-5068

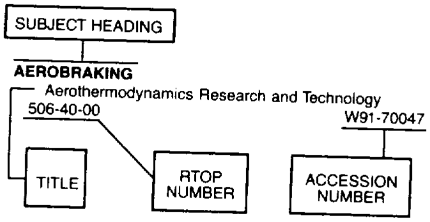
The objective is to demonstrate the operation in space of hollow cathode (HCA) plasma contactors to provide closure to and from the ionosphere of large currents at low voltage from both ends of an electrodynamic tether wire, to produce a 'Plasma Motor-Generator' system suitable for both on-orbit propulsion and electrical power generation. The PMG is scheduled as a secondary payload for flight on a Delta II in mid 1992.

906-30-04

W91-70478
Marshall Space Flight Center, Huntsville, AL.
FLIGHT EXPERIMENTS
James K. Harrison 205-544-0629

The objective of the Small Expendable Deployer System (SEDS) is to complete the integration of SEDS into the Delta 2 expendable launch vehicle for a 1991 flight. The three key integration tasks remaining are (1) analysis to determine the type and extent of mods needed by Delta 2 to accommodate SEDS; (2) design and development (or procurement) of special hardware and systems to accommodate SEDS, i.e., batteries, thermal protection system, and mounting brackets; (3) launch site operations, i.e., physical integration, last minute electrical tests and check-out. The secondary objective is to manufacture four complete sets of hardware for follow-on SEDS flights. The objective of the proposed flight experiment, Fluid Acquisition and Resupply Experiment (FARE), is to evaluate passive devices designed for low gravity liquid acquisition and transfer. Orbital propulsion operations and satellite servicing continue to be constrained by a lack of flight data and experience involving low gravity fluid behavior. Significant logistical and crew utilization penalties are incurred using state-of-the-art fluid resupply methods. The proposed approach is to evaluate the performance of two liquid acquisition devices (LAD's) that use capillary forces to separate liquid and vapor. This evaluation will utilize a previously flown test facility, the Storable Fluid Management Demonstration (SFMD), configured with screen channel and vane LAD's. This approach will enable essential low gravity fluids data to be obtained in a cost effective and timely manner.

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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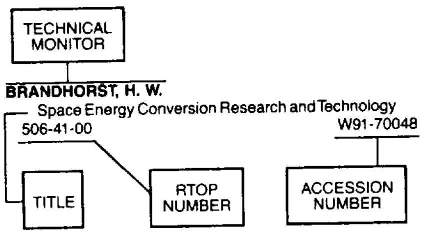

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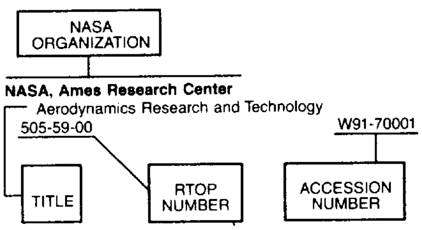
Typical Responsible NASA Organization Index Listing



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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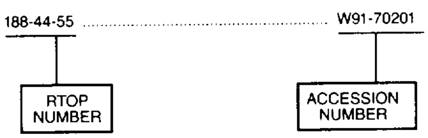
Typical RTOP Number Index Listing



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16. Abstract

This publication represents the NASA research and technology program for FY 1991. 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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