Research and Technology Objectives and Plans
Summary

Fiscal Year 1993
Research and Technology Program

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INTRODUCTION

This publication represents the NASA Research and Technology Program for FY 1993. 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.

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, DC 20546-0001
Attn: Edna Templeton
Deputy Director, Resources and Management Systems Office (RB)

Glenn Fuller
Director, Resources and Management Systems Office
Office of Aeronautics and Space Technology
# TABLE OF CONTENTS

Office of Aeronautics and Space Technology  

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AERONAUTICS RESEARCH AND TECHNOLOGY BASE</strong></td>
<td>1</td>
</tr>
<tr>
<td>Aerodynamics R&amp;T</td>
<td>1</td>
</tr>
<tr>
<td>Propulsion and Power R&amp;T</td>
<td>1</td>
</tr>
<tr>
<td>Materials and Structures R&amp;T</td>
<td>2</td>
</tr>
<tr>
<td>Controls, Guidance and Human Factors R&amp;T</td>
<td>3</td>
</tr>
<tr>
<td>Flight Systems R&amp;T</td>
<td>3</td>
</tr>
<tr>
<td>Systems Analysis</td>
<td>4</td>
</tr>
<tr>
<td>Hypersonic R&amp;T</td>
<td>4</td>
</tr>
<tr>
<td>Interdisciplinary Technology</td>
<td>5</td>
</tr>
<tr>
<td><strong>AERONAUTICS SYSTEMS TECHNOLOGY PROGRAMS</strong></td>
<td>6</td>
</tr>
<tr>
<td>High-Performance Computing</td>
<td>6</td>
</tr>
<tr>
<td>Materials &amp; Structures Systems Technology</td>
<td>8</td>
</tr>
<tr>
<td>Rotorcraft Systems Technology</td>
<td>8</td>
</tr>
<tr>
<td>High-Performance Aircraft Systems Technology</td>
<td>9</td>
</tr>
<tr>
<td>Advanced Propulsion Systems Technology</td>
<td>9</td>
</tr>
<tr>
<td>Numerical Aerodynamic Simulation</td>
<td>10</td>
</tr>
<tr>
<td>High-Speed Research</td>
<td>10</td>
</tr>
<tr>
<td>Advanced Subsonic Technology</td>
<td>12</td>
</tr>
<tr>
<td><strong>SPACE RESEARCH AND TECHNOLOGY BASE</strong></td>
<td>13</td>
</tr>
<tr>
<td>Aerothermodynamics R&amp;T</td>
<td>13</td>
</tr>
<tr>
<td>Space Energy Conversion R&amp;T</td>
<td>13</td>
</tr>
<tr>
<td>Propulsion R&amp;T</td>
<td>14</td>
</tr>
<tr>
<td>Materials and Structures R&amp;T</td>
<td>15</td>
</tr>
<tr>
<td>Space Flight R&amp;T</td>
<td>16</td>
</tr>
<tr>
<td>Systems Analysis</td>
<td>17</td>
</tr>
<tr>
<td>University Space Research</td>
<td>18</td>
</tr>
<tr>
<td>Information and Controls R&amp;T</td>
<td>18</td>
</tr>
<tr>
<td>Human Support R&amp;T</td>
<td>20</td>
</tr>
<tr>
<td>Space Communications R&amp;T</td>
<td>20</td>
</tr>
<tr>
<td>Hypersonic R&amp;T</td>
<td>22</td>
</tr>
<tr>
<td>In-Space Technology Experiments</td>
<td>22</td>
</tr>
<tr>
<td>Interdisciplinary Technology</td>
<td>23</td>
</tr>
<tr>
<td><strong>CIVIL SPACE TECHNOLOGY INITIATIVE PROGRAM</strong></td>
<td>24</td>
</tr>
<tr>
<td>Space Science Technology</td>
<td>24</td>
</tr>
<tr>
<td>Planetary Surface Technology</td>
<td>25</td>
</tr>
<tr>
<td>Transportation Technology</td>
<td>25</td>
</tr>
<tr>
<td>Space Platforms Technology</td>
<td>27</td>
</tr>
<tr>
<td>Operations Technology</td>
<td>27</td>
</tr>
</tbody>
</table>
## Office of Space Science and Applications

<table>
<thead>
<tr>
<th>Program Area</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planetary Geology/Geophysics</td>
<td>31</td>
</tr>
<tr>
<td>Planetary Materials/Geochemistry</td>
<td>31</td>
</tr>
<tr>
<td>Planetary Atmospheres R&amp;A</td>
<td>33</td>
</tr>
<tr>
<td>MARS Data Analysis</td>
<td>35</td>
</tr>
<tr>
<td>Planetary Instrument Definition</td>
<td>36</td>
</tr>
<tr>
<td>Solar Terrestrial SR&amp;T</td>
<td>37</td>
</tr>
<tr>
<td>Advanced Programs</td>
<td>38</td>
</tr>
<tr>
<td>Solar Terrestrial &amp; Astrophysics SR&amp;T</td>
<td>39</td>
</tr>
<tr>
<td>Planetary Astronomy</td>
<td>45</td>
</tr>
<tr>
<td>Life Sciences SR&amp;T</td>
<td>46</td>
</tr>
<tr>
<td>Solar Terrestrial Mission Operation and Data Analysis</td>
<td>51</td>
</tr>
<tr>
<td>Astrophysics Mission Operations and Data Analysis</td>
<td>52</td>
</tr>
<tr>
<td>EOS Data Information System</td>
<td>53</td>
</tr>
<tr>
<td>EOS Science</td>
<td>55</td>
</tr>
<tr>
<td>Space Physics Theory</td>
<td>58</td>
</tr>
<tr>
<td>Space Physics SR&amp;T</td>
<td>58</td>
</tr>
<tr>
<td>Space Physics ATD</td>
<td>59</td>
</tr>
<tr>
<td>Space Physics Sounding Rocket Research</td>
<td>59</td>
</tr>
<tr>
<td>Spacelab Payload Instrument Development/Astrophysics</td>
<td>59</td>
</tr>
<tr>
<td>Origins of Solar Dynamics</td>
<td>60</td>
</tr>
<tr>
<td>Radiation and Dynamic Processes</td>
<td>61</td>
</tr>
<tr>
<td>Hydrologic Processes</td>
<td>63</td>
</tr>
<tr>
<td>Ecosystem Processes</td>
<td>67</td>
</tr>
<tr>
<td>Biogeochemical Processes</td>
<td>70</td>
</tr>
<tr>
<td>Atmospheric Processes</td>
<td>72</td>
</tr>
<tr>
<td>Solid Earth Processes</td>
<td>75</td>
</tr>
<tr>
<td>Climate and Hydrologic Systems Modeling and Data Analysis</td>
<td>82</td>
</tr>
<tr>
<td>Biogeochemistry and Geophysics Modeling and Data Analysis</td>
<td>88</td>
</tr>
<tr>
<td>Data Systems</td>
<td>93</td>
</tr>
<tr>
<td>Mission Operations and Data Analysis</td>
<td>97</td>
</tr>
<tr>
<td>Search and Rescue Mission</td>
<td>99</td>
</tr>
<tr>
<td>Space Processing Science and Spacelab Payload Development</td>
<td>99</td>
</tr>
<tr>
<td>Sounding Rockets</td>
<td>102</td>
</tr>
<tr>
<td>Mission Operations and Data Analysis</td>
<td>102</td>
</tr>
</tbody>
</table>

## Office of Space Communications

<table>
<thead>
<tr>
<th>Program Area</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Systems</td>
<td>103</td>
</tr>
</tbody>
</table>

### Indexes

<table>
<thead>
<tr>
<th>Index</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Index</td>
<td>I-1</td>
</tr>
<tr>
<td>Technical Monitor Index</td>
<td>I-73</td>
</tr>
<tr>
<td>Responsible NASA Organization Index</td>
<td>I-81</td>
</tr>
<tr>
<td>RTOP Number Index</td>
<td>I-87</td>
</tr>
</tbody>
</table>
The objectives of this program are to: (1) determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur as the result of thermal annealing, hydration, and exposure to cosmic rays. The result will be the characterization of the grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored via quadrupole mass spectrometer. Objectives 2 and 3 require a separate flow system designed to produce grains rather than clusters and able to produce large amounts of multicomponent smokes. 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 induced changes studied by the above techniques. Accomplishment of objectives 2 and 3 also require 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.
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology

Aerodynamics Research and Technology

W93-70001 (21) 505-59
Ames Research Center, Moffett Field, CA.

The objectives are: (1) to improve the understanding of the physics that influence vehicle aerodynamics and propulsion performance of components and complete configurations for the design of future aircraft, (2) to develop single and multidisciplinary analysis and design methodologies enabling the rapid design and development of future aircraft, and (3) to develop test techniques, measurement technologies, and facility concepts to support improved prediction techniques and improved analysis and design methodologies. The approach will be based on a synergistic combination of computer simulations and experimental testing. The necessary elements that comprise applications software for numerical modeling of fluid dynamic flows will be created, refined or modified. Wind tunnel experiments will be conducted to understand fluid physics, develop databases for turbulence modeling and validate computer programs.

W93-70002 (23) 505-59
Langley Research Center, Hampton, VA.

The objective is to develop an advanced and validated base of new aerodynamics technology for application to future generations of civil aircraft, and rotorcraft, and fighter aircraft. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objectives. Wind tunnel tests and consultation to DoD, industry, and other agencies are provided consistent with available resources. This work is expected to result in advanced aerodynamic technologies for application by the aircraft industry in developing more efficient subsonic, supersonic, and hypersonic aircraft.

W93-70003 (55) 505-59
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

This part of the Transition/Turbulence Element of the Aerodynamics R&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 to produce and modify 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 aerodynamic surfaces, the research will encompass two- and three-dimensional incompressible, subsonic, transonic, supersonic and hypersonic boundary layers.

Propulsion and Power Research and Technology

W93-70004 (22) 505-62
Lewis Research Center, Cleveland, OH.

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. This work is to develop new technologies for government and industry propulsion system development. In the subsonic regime, research is aimed at reducing the fuel consumption of the large high-bypass-ratio turbofan engines powering the large transport aircraft and that of the small engines for rotorcraft and commuters by as much as 30 percent, reducing the fuel consumption of the rotary engine for general aviation by 40 percent, improving helicopter transmissions and reducing the noise of the turbofan engines by as much as 10 db. Research in supersonic propulsion focuses on advanced concepts for supersonic cruise which include vectoring nozzles, the supersonic throughflow fan, combined cycle turboramjets, variable geometry inlets and integrated flight/propulsion controls. Key tools will continue to be developed to enhance these research efforts: advanced computational methods for numerically modeling internal flows; nonintrusive measurement techniques; advanced
Materials and Structures Research and Technology

W93-70006 (21) 505-63
Ames Research Center, Moffett Field, CA.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
V. M. DeAngelis 805-258-3921
The objectives are to provide the materials and structures research and technology (R&T) necessary for significant improvements in the design, analysis, and structural performance of future generation aircraft: to develop techniques to enhance strain gage load calibration/measurement methods; and to develop and demonstrate advanced structural excitation systems and new real-time algorithms for flight flutter clearance testing. The approach will be to: (1) conduct in-house and contract/grant studies to develop improved methods for strain gage location, calibration, and equation derivation for structural load measurement; (2) apply these techniques to existing aircraft structures for validation using experimental data obtained from both laboratory grounds tests and flight tests; (3) contract to small high technology businesses for the development of structural excitation systems, and evaluate the performance of these systems using currently available test bed aircraft; and (4) sponsor university grants for the development of real-time flutter analysis algorithms to be evaluated in the flight test environment.

W93-70007 (10) 505-63
National Aeronautics and Space Administration, Washington, DC.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Kristin A. Hessenius 202-453-2810
The objective is to conduct fundamental research on advanced materials concepts for aeronautics. Advisory services to guide Research and Technology 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) was 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.

W93-70008 (22) 505-63
Lewis Research Center, Cleveland, OH.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. E. Lowell 216-433-3191
There are two major objectives of this RTOP. The first is 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 emphasis of this work is directed toward developing a greater understanding of and modeling of the interrelationships among material composition/microstructure, fabrication processes, and mechanical/physical properties. The second major objective is to develop and verify advanced analysis and synthesis methods, advanced generic structural concepts, and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components. In addition, improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems will be developed and experimentally validated. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems. This work is expected to result in advanced materials systems for future application by industry for high performance, more fuel efficient airpropulsion systems.

W93-70009 (23) 505-63
Langley Research Center, Hampton, VA.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005
The objectives of this research are to provide structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. The approach includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) aerelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics, thermal structures, and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) structural acoustics; (5) fatigue, fracture analysis, and life prediction; and (6) interdisciplinary analysis and optimization. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. The customers include the U.S. aircraft and rotorcraft industries, FAA, DOD, military aircraft industry, and the U.S. airline industry. Applications include aircraft structural design, aircraft materials and fabrication technologies, aeroelastic stability, and aircraft ground operations.
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Controls, Guidance, and Human Factors Research and Technology

W93-70010  (21) 505-64
Ames Research Center, Moffett Field, CA.

CONTROLS, GUIDANCE, AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

J. A. Albers  415-604-5070

The objective is 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 and air traffic control network operations. The approach will be to conduct analytic, field, and laboratory studies and evaluate concepts with in-flight simulation and flight demonstrations. Research will be conducted on control systems for superaugmented aircraft as well as control, guidance, and display systems to achieve more effective 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 light attack aircraft. This is closely coupled with human factors research which focuses on providing requirements, guidelines, procedures, and technology concepts for piloting, air traffic control, and ground support operations in a human-centered design approach for efficient automation interfaces with human capabilities; developing tools for the design and evaluation of crew/cockpit interfaces and operational procedures to support more effective crew performance, and improving aviation system reliability and precision.

W93-70011  (23) 505-64
Langley Research Center, Hampton, VA.

CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

J. F. Creedon  804-864-6033

The objective of this RTOP is to provide the controls, guidance, and human factors research and technology (R&T) needed for continued improvements to all weather operational performance, efficiency, safety, reliability, and competitiveness of U.S. subsonic, supersonic, and high performance aircraft. Specific objectives include: development, validation, and demonstration of tools and methods for generating and evaluating reliable software and designing fault tolerant, electromagnetic environment (EME) resistant digital flight systems; application of advanced controls, displays, and decision making aids to increase cockpit efficiency, and enhance airport terminal area productivity; multi-disciplinary efforts to develop and validate airborne wind shear detection/avoidance techniques; development and evaluation of advanced flight decks concepts for future aircraft; development of design methods for advanced high performance aircraft guidance and control (G&C) systems; providing advanced antenna analysis and design technology for all aircraft classes; development and validation of models and crew performance measures for detection of pilot/crew workload and awareness state; exploration of parallel computing system issues and evaluation of computer architectures; and investigation of computing technologies to achieve large performance increases. The approach taken includes establishing basic concepts and theories, developing and validating new concepts and innovative techniques through analysis, simulation, laboratory testing, and demonstration of the most promising concepts in flight tests. Computer science research is augmented through activities at the University of Illinois and LaRC sponsored ICASE Flight crucial systems and software reliability and fault tolerance, flight management, flight deck design, controls, and human engineering technology developed under this RTOP directly supports and influences the design, development, and operation, by U.S. airframe manufacturers and airlines, of current and future subsonic and supersonic transport aircraft and enhances their safety, reliability, competitiveness, and productivity. In addition, this RTOP provides research products that contribute to the control, maneuverability, survivability, and operation of future high performance military aircraft. Transfer of technology from this RTOP to industry/government users is accomplished through a combination of workshops, cooperative agreements, industry tours, publications and conferences, as well as direct contacts initiated by either LaRC or industry researchers.

W93-70012  (51) 505-64
Goddard Space Flight Center, Greenbelt, MD.

CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY

B. L. Shaw  804-824-1654

The objective is to provide appropriate support to OAST research activities at the WFF Research Airport. This is focused around a variety of new and ongoing OAST programs. The support effort will be organized and implemented by project engineers and will include airport management, engineering, and maintenance; instrumentation and equipment purchases; fuel and other stock issues; and contractual services for aircraft fuel operations, control tower operations, line service support, crash-fire and rescue standby, and miscellaneous shop support.

Flight Systems Research and Technology

W93-70013  (21) 505-68
Ames Research Center, Moffett Field, CA.

FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY

D. H. Gatlin  805-258-3166

The overall objective is to provide the necessary research and technology development of advanced flight systems for application to future military and civil aircraft. This includes the necessary supportive development of testing techniques and instrumentation to enhance data accuracy. Research will be conducted as part of the NASA High-Angle-of-Attack Technology Program. Flight tests of the X-31 aircraft will also be conducted to validate integrated technologies and maneuver benefits. Flight experiments will be conducted using the High Alpha Research Vehicle (HARV). Unconventional approaches for high alpha flight control and maneuvering will be investigated. 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. A modern set of testbed aircraft will be established to support NASA developed flight systems research experiments. High speed experiments will be conducted on the SR-71 aircraft.

W93-70014  (22) 505-68
Lewis Research Center, Cleveland, OH.

FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY

J. A. Ziemiański  216-433-3901

The overall objective of this effort is to provide for the necessary research and technology (R&T) development of advanced flight systems concepts for application to future military and civil aircraft. This part of the flight systems R&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 aircraft. The current plans for this research area are to develop analytical and experimental icing 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 high performance aircraft. This work is expected to result in the design.
of and analytical tools for future high performance aircraft. Improved analytical and experimental icing simulation techniques will help airframers reduce dependence on expensive and high risk flight testing in natural icing conditions. Advanced ice protection concepts provide airframers with alternatives to anti-icing by hot compressor bleed air, which will not be available from future high-bypass engines.

W93-70015  (23)  505-68
Langley Research Center, Hampton, VA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
Roy V. Harris, Jr.  804-864-6048
The objectives of this RTOP are to develop advanced methods and vehicle concepts needed to significantly increase fighter maneuverability and agility considering the effects of high-angle-of-attack, vortex flows, unsteady aerodynamics, thrust vectoring, and advanced control laws and cockpit displays; and utilize flight experiments to validate key elements. This work will provide high-angle-of-attack technology in the areas of aerodynamics, advanced controls, and maneuver management for future applications by the industry and DOD in developing high-performance aircraft with greatly enhanced agility and combat effectiveness.

Systems Analysis

W93-70016  (21)  505-69
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
G. H. Kidwell  415-604-5886
There are two primary objectives to this RTOP. The first is to provide information for guiding the planning of advanced aircraft research, technology development, and flight research programs. Current efforts in this RTOP are directed toward advanced tiltrotor transports and toward defining broad aeronautics research requirements. The second objective is to develop advanced design and analysis methodology to improve both in-house and industry capabilities in design optimization and concurrent engineering. This multidisciplinary research is performed in support of Critical Disciplines objectives. The fundamental approach to these objectives is through analytical method development and application. 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. Most in-house compilations are performed on engineering workstations. Other methods of acquiring supporting data, such as wind tunnel tests or piloted simulations, are used occasionally to support the design process.

W93-70017  (10)  505-69
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Cecil C. Roson, III.  202-453-2789
This effort supports the overall planning and management of the Aeronautics Research and Technology program. Activities include a studies contract in support of OAST aeronautics technology program requirements, assessments, planning, and advocacy; membership in the Radio Technical Commission for Aeronautics (RTCA); and funding for the University Advanced Aeronautical Design Studies Program.

W93-70018  (22)  505-69
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
D. C. Mikkelsen  216-977-7011

Studies will be conducted to establish the feasibility and potential benefits of advanced subsonic and supersonic propulsion concepts in order 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. Near term and long range aeropropulsion planning will be conducted to assist in the development of future NASA aeronautics programs. This work is expected to result in the identification of new/advanced airbreathing propulsion systems for the U.S. aeronautical industry that will lead to quieter, cleaner, more efficient civil aircraft, military aircraft having new/unique performance capabilities, and the ability to make such determinations in a shorter time and with greater modeling fidelity.

W93-70019  (23)  505-69
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
Roy V. Harris, Jr.  804-864-6048
The objective of this RTOP 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 improvements or advancements 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 development. This research is expected to result in integrating discipline technologies for evaluation and identification of high payoffs for focused subsonic and supersonic vehicle programs for future development by industry.

Hypersonic Research and Technology

W93-70020  (21)  505-70
Ames Research Center, Moffett Field, CA.
HYPERSONIC RESEARCH AND TECHNOLOGY
K. L. Peterson  805-258-3189
The overall objectives are to advance fundamental understanding of basic physical and chemical processes and to develop predictive capabilities for analysis and design optimization of advanced airbreathing hypersonic vehicles. A synergistic interplay between computational, ground-based experimental, and flight research will be used to validate the technology. These efforts will provide the prerequisite research and technology (R&T) developments enabling an improved and validated technology base for application by industry in the development of future generation hypersonic flight vehicles. There are six efforts to be carried out. The first will be to develop the computational and experimental technologies required to accurately predict the aerodynamic and aerothermal characteristics of highly integrated, airbreathing hypersonic vehicles. The second will be to provide the experimental techniques and computational capabilities required to accurately simulate hypersonic propulsion flowfields and operating conditions. The third will be to provide the materials and structures R&T necessary for industry to make significant improvements in the performance, durability, and economy of future generation hypersonic aircraft operating at extreme temperatures. The fourth will be to develop the multidisciplinary modeling and analysis technology required to fully utilize advanced controls integration concepts on hypersonic vehicles and to conduct total vehicle
stability and dynamics response analyses. The fifth will be to establish, through conceptual design studies and systems analysis, the impacts of projected technological developments, alternate configuration approaches, and different mission requirements on the feasibility of advanced hypersonic vehicles. The sixth will be to provide a hypersonic experimental database of sufficient accuracy to calibrate/validate advanced Computational Fluid Dynamics (CFD) and engineering design codes used in the prediction of aerodynamic, propulsion, structural, thermal, and controls characteristics encountered on future hypersonic vehicles.

W93-70021 505-70-00
National Aeronautics and Space Administration, Washington, DC.

HYPERSONIC TRAINING AND RESEARCH
John S. Fyle 202-435-2744

The objective of this RTOP is to provide U.S. colleges and universities with increased focus and emphasis on the training and development of future researchers and technologists in the field of hypersonic aeronautics. In FY-1987, a jointly funded AF/Navy/NASA program was initiated to assist six academic institutions (selected by open competition) to develop graduate-level curriculum for training students in the study of flow physics associated with atmospheric flight at hypersonic speeds. In this initial program, curriculum development and basic research was primarily directed toward aerodynamic viscous flow phenomena in the Mach 5 to 15 flight regime. The program provided opportunities for conducting leading-edge research to train graduate students in preparation for careers in the government and U.S. industries. The initial grants with the six colleges and universities are to be completed in FY-1992. This highly successful program directly supported and graduated approximately 72 Master degrees, 57 Doctorate degrees (and indirectly supported numerous undergraduate students), and has been responsible for publishing over 256 technical reports and papers including over 26 major invited presentations for both national and international conferences in the five years of its existence. The intent of the current RTOP is to initiate a competition for the selection of new colleges and universities to participate in the program and to assure its continuation. The principal fields of study will be expanded to include hypersonic air-breathing propulsion, materials and structures, controls, and system integration research in addition to basic aero/aerothermodynamic flow physics.

W93-70022 505-70-00
Lewis Research Center, Cleveland, OH.

HYPERSONIC RESEARCH AND TECHNOLOGY
John E. Rohde 216-433-3949

The broad objective of the focused Hypersonic Research Program is to provide an enabling fundamental technology base and design methodology for airbreathing, hypersonic propulsion systems. Both hydrogen-fueled and hydrocarbon-fueled propulsion systems will be investigated to understand the physics of the high speed flow that exists in the components of these engines. Computational Fluid Dynamics (CFD) methods and models will be developed that will permit the design of these very complex and highly integrated engines, and non-intrusive diagnostic measuring systems will be developed and applied to verify the methods and design. Advanced materials and advanced structures will be developed with the strength-to-weight and go/return capability that will enable the airbreathing engines and vehicles. Synthesis studies will be conducted on hypersonic vehicles to establish feasibility, assess potential benefits, and define critical technology needs. Focused research efforts will be pursued in five areas. The first area to be pursued will be propulsion flowpath and component development, analysis, and experimental testing. The research will verify the compatibility of an engine flowpath to function both as a scramjet at hypersonic speeds and as a thermally choked ramjet at lower speed conditions. The second effort will be to develop and verify improved CFD Methods and models to predict components and nose-to-tail integrated propulsion systems. The research will enhance the RPLUS code with higher-order upwind methods and 3-D grid overlay capabilities, and utilize probability density function turbulence modeling in improved CFD codes. The third effort will be to develop and apply nonintrusive diagnostic instrumentation technology to understand the hypersonic flow in inlets and propulsion systems. The fourth effort will be to assess the potential benefits of and critical technology needs of both two-stage-to-orbit transatmospheric vehicles and Mach 5 cruise vehicles. The research will refine the thermal management and structural weight analysis of the propulsion systems. The final effort will be to develop high temperature, high conductivity reinforced Gr/Cu composites with advanced fibers and/or processes for actively cooled engine panels with seals to enable variable geometry. The investigation will implement a new viscoplastic model in the MARC code for improved stress/strain life prediction of Gr/Cu composites. This work will provide fundamental propulsion technology base and design methodology that will enable the industry to develop complete classes of transatmospheric and hypersonic cruise vehicles. These vehicles will provide major benefits in terms of reduced cost of payload to orbit, life cycle cost, and operational flexibility and performance in terms of efficiency, range, and controlled hypersonic flight.

W93-70023 505-70-00
Langley Research Center, Hampton, VA.

HYPERSONIC RESEARCH AND TECHNOLOGY
L.M. Couch 804-864-3736

This research includes executing experimental and analytical programs to develop new, advanced technology in all areas of hypersonics: aerodynamics, propulsion, materials and structures, guidance and control, and systems analysis and multi-disciplinary integration. In addition, supporting the advances in these areas is research aimed toward the development of advanced test techniques, test support methods, and measurement technology. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. Results of this research will enable the development of efficient, viable hypersonic vehicles of all types, including reusable launch vehicles (both single and two stage) and cruise vehicles.

Interdisciplinary Technology

W93-70024 505-90-00
Ames Research Center, Moffett Field, CA.

INTERDISCIPLINARY TECHNOLOGY
C. Smith 415-604-5113

The objective of this RTOP is to promote and conduct innovative, leading-edge research in aeronautics through research and training grants, cooperative research efforts, and joint research institutes. The objectives are met through three elements within the RTOP: the Fund for Independent Research; the Graduate Program in Aeronautics, and the Joint University Institutes. The Fund for Independent Research supports innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. The Graduate Program in Aeronautics provides grants to support graduate training and research in aeronautics. A significant portion of this training will be through student research conducted at ARC, the Joint University Institute provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics (JIIA) and the Research Institute for Advanced Computer Science (RIACS). The JIIA promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics. The RIACS pursues advances in computer science and computational methods required for long-range NASA goals.
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 administration of reviews, studies, and assessments of the ongoing and planned programs by the Aeronautics and Space Engineering Board (ASEB); and multidisciplinary training and research. The RRA program and the ASEB activities are contracted efforts, and the multidisciplinary training and research will be university grants.

M. E. Goldstein  216-433-5825

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term, university-type research through research and training grants, cooperative research efforts, and joint research institutes and activities. The program allows the Office of Aeronautics and Space Technology (OAST) to initiate fundamental studies in areas not presently included in a specific discipline program, to enhance LeRC's involvement with the academic community, and to sponsor graduate training in aeronautics. It is accomplished through five programs: (1) Fund for Independent Research; (2) Graduate Program in Aeronautics; (3) Institute for Computational Mechanics in Propulsion (ICOMP); (4) Lewis Research Academy; and (5) Ohio Aerospace Institute (OAI). The Fund for Independent Research support long-range, high-risk basic research activities at universities that are related to NASA's aeronautics activities. The Graduate Program in Aeronautics sponsors graduate training and research in areas that are relevant and acceptable to both NASA and the universities. These two programs involve grants which are selected by the members of the Lewis Research Advisory Board, who, at the request of the Chief Scientist, review unsolicited research proposals and proposals received in response to announcements of research opportunities. Those research proposals that are judged by the Chief Scientist to be worthy of support on a scientific or engineering basis are selected as candidates for funding. These proposals are then prioritized and funded to the extent permitted by available resources. The Lewis Research Academy consists of a group of internationally recognized basic researchers under the general cognizance of the Chief Scientist. Its primary purpose is to ensure that present and future Lewis programs achieve the maximum benefit from Lewis basic research activities. The objective of the Institute for Computational Mechanics in Propulsion is to develop accurate computer simulations for propulsion systems components as well as complete engine simulations. The objective of the Ohio Aerospace Institute is to expand Center involvement with the university community. The research supported under this RTOP is likely to lead to new technologies and concepts that will in turn lead to more fuel-efficient aircraft engines and new generations of aircraft engines that can operate at higher speeds and with improved performance.

M. F. Card  804-884-6062

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) the 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 research that is relevant 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 student research is conducted 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. The application of this RTOP for NASA is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research and to increase the pool of American aerospace graduate students. The customers are as follows: (1) NASA, which receives innovative research results and training for its personnel in state-of-the-art academic methods and technology; (2) the aerospace industry, which hires highly-qualified graduate students who participate with university faculty in the research projects; and (3) university aerospace departments, which are able to use the funding to improve the quality of their research, students, and faculty.
serve as proof of concept; and the establishment of scalable testbed systems. The computational aeroscience activities and scalable testbed systems at ARC, LaRC and LeRC will be interconnected over T3 broadband Integrated Services Digital Network (ISDN) services which are the NASA part of the National Research and Education Network (NREN) program.

**W93-70030**

(22) 509-10

**LEWIS RESEARCH CENTER, CLEVELAND, OH.**

**COMPUTATIONAL AEROSCIENCES**

Lester D. Nichols 216-433-3213

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

**W93-70031**

(23) 509-10

**LANGLEY RESEARCH CENTER, HAMPTON, VA.**

**COMPUTATIONAL AEROSCIENCE**

Roy V. Harris, Jr. 804-864-6048

As part of the High-Performance Computing and Communications program, the goal of the Computational Aerosciences (CAS) Project at NASA LaRC is to develop necessary computational technology for the numerical simulation of complete aerospace vehicles for both design optimization and analysis throughout the flight envelope. The goal is supported by four specific objectives: to develop multidisciplinary computational models and methods for scalable, parallel computing systems; to accelerate the development of computing system hardware and software technologies capable of sustaining teraflops performance level on computational aeroscience applications; to demonstrate and evaluate computational methods and computer systems technologies for selected aerospace vehicle and propulsion systems models on scalable, parallel computing systems; and to transfer computational methods and computer systems technologies to aerospace and computer industries. The general strategy of the project is to achieve understanding of all aspects of complete future implementations of CAS grand challenge applications on fully scaled teraflops computing systems through a series of controlled limited-scope experiments utilizing grand challenge based subproblems and testcases. The CAS project at LaRC will focus on a high-speed civil transport (HSCT).

**W93-70032**

(21) 509-20

**AMES RESEARCH CENTER, MOUNTFIELD, CA.**

**EARTH AND SPACE SCIENCES**

K. G. Stevens, Jr. 415-604-5049

The objective is to interconnect the NASA Science Centers to the National Research and Education Network (NREN). The approach will be the immediate development and implementation of an interim high performance network and the piloting of gigabit network technologies for implementation in the mid 1990s. These efforts will be carried out in collaboration with other agencies in the federal government. Specifically, NASA's NREN effort will support the interconnection of the NASA centers participating in the Federal High Performance Computational Communication Program (HPCCP) at speeds in the multimegabit range (45 Mbps and up) and develop additional connectivity (with new and other existing networks) to satisfy Earth and Space Sciences grand challenges. GSFC and JPL will be attached to the NSF T3 network for connectivity to remote investigators and to the Level 2 network (fast-packet, protocol independent) for inter-center connectivity. As a major NREN partner and user, the NREN project team will work with NSF, DOE and DARPA to enhance the national network services such as resource management, routing control, security, user services and advanced operations. NREN will be supporting the High Performance Computing and Communication National Software Exchange which is managed by GSFC. Ames will develop DAVID 'books' to represent widely differing categories of data in support of GSFC.

**W93-70033**

(10) 509-20

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC.**

**EARTH AND SPACE SCIENCES**

Lee H. Holcomb 202-453-2587

The objectives of the High Performance Computing and Communications (HPCC) program will be to: (1) accelerate the development of computing hardware and software technologies capable of sustaining a teraflops performance level on Earth and space sciences applications; and (2) develop the next generations of computer and computational scientists. The approach will be to establish high performance computing testbeds and constitute application software teams to utilize and evaluate them, and to provide funds for grants and fellowships to students and faculty members interested in Earth and space sciences.

**W93-70034**

(51) 509-20

**Goddard Space Flight Center, Greenbelt, MD.**

**EARTH AND SPACE SCIENCES**

J. M. Hollis 301-286-7591

The goal of this RTOP is to accelerate the development and application of high performance computing technologies to meet the computational needs in numerical modeling and data analysis of the U.S. Earth and Space Science community. NASA-related Grand Challenges in science and data management serve as case studies for the test and evaluation of scalable parallel computing systems. The focus is on multidisciplinary applications involving a broad range of simulation and analysis. A NASA Research Announcement (NRA) was jointly issued by the Office of Aeronautics and Space Technology (OAST) and the Office of Space Science and Applications (OSSA) in FY-92 soliciting proposals from physical, computational, and computer scientists. NASA Grand Scientific Challenge applications may come from any NASA science discipline and are chosen for their potential direct impact to NASA, their national importance, and the technical challenge they give to the program. A peer review process will select 4 to 6 critical mass Principal Investigator Teams to make progress toward solution of proposed Grand Challenge problems, and also will select 10 to 20 individual Guest Computational Investigators to develop related algorithms specifically for scalable parallel architectures. This RTOP will develop the High Performance Computing Software Exchange to provide an infrastructure that encourages Software Exchange to provide an infrastructure that encourages software reuse and the sharing of software modules across organizations through a uniformly interconnected set of software repositories. NASA has the responsibility for coordinating this activity for the Federal High Performance Computing and Communication (HPCCP) Program. The objectives of this RTOP are as follows: (1) to develop algorithms and architecture testbeds capable of fully utilizing massively parallel concepts and scalable to sustained teraflops performance; (2) to create a generalized software environment for massively parallel computing applications; and (3) to demonstrate the impact of these technologies on NASA research in Earth and space sciences physical phenomena. The objectives are approached as follows: (1) to use a NASA Research Announcement (NRA) to select Grand Challenge Applications and Principal Investigator Teams that require teraflops computing for NASA science problems; (2) to provide successive generations of scalable computing systems as testbeds for the Grand Challenge applications, interconnect the investigators and the testbeds through high speed network links, provide a software development environment, and supporting computational techniques of the investigators; and (3) in collaboration with the investigator teams that will select the next generation of scalable teraflops testbeds.
Materials and Structures Systems Technology

W93-70036 (22) 510-01
Lewis Research Center, Cleveland, OH.

ADVANCED HIGH TEMPERATURE ENGINE MATERIALS
H. R. Gray 216-433-3230

The objectives of this work are to provide for the development of high temperature composite materials including the structural analysis methods required to do property, life, and failure mechanisms predictions and to provide the necessary technology to permit the transition of these innovative materials to applications in 21st century propulsion systems. Multidisciplinary development of technology for high temperature composites including ceramic, intermetallic, and polymeric will be conducted. Fiber/matrix combinations will be selected using thermodynamic and structural considerations for the development of composite structural materials for high temperature propulsion applications. A detailed understanding of composite architecture, processing, fiber/matrix interaction, life prediction and projected failure mechanisms will be developed for these advanced materials for use at temperatures up to 3000 F. Studies to synthesize matrix resins for use at 800 F with high toughness will be conducted. Revolutionary processing concepts will be explored for all classes of materials being developed under this program. Supporting technologies will be developed in high temperature sensors, nondestructive evaluation, and loads definition to insure an ability to take data at high temperatures on known quality materials under the correct stress and strain boundary conditions. Industry involvement and participation will be actively sought to insure both information transfer and the development of materials with the highest potential for transfer to product usability. This work is focused on the development of 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.

W93-70037 (22) 510-02
Lewis Research Center, Cleveland, OH.

ADVANCED COMPOSITE MATERIALS TECHNOLOGY
C. C. Chams 216-433-3252

This RTOP effort is a part of the Advanced Composite Technology (ACT) program and has the specific objective to develop a formal framework (methods/computer codes) to quantify the reliability and risk in aircraft composite structures and thus minimize the effort and time required to certify and fly these types of structures. The formal framework will be developed by considering probabilistic structural analysis methods (available from the durability program for the Space Shuttle Main Engine, (SSME) with probabilistic composite mechanics (micro and macro mechanics, laminate behavior, delaminations, fatigue and life, durability environmental effects, and structural fracture via progressive damage). The product will be a computer code for the Integrated Probabilistic Assessment of Composite Structures (IPACS). IPACS will simulate all aspects of composite structural behavior and structures as well as joints. IPACS will be jointly developed by Lewis personnel with the aid of support service contractors and with strong participation from aircraft industry and academia who also participate in the ACT program. IPACS will account for all possible failure modes in composite structures and will be verified by the industrial participants who will ultimately use it in the certification process of composite aircraft. The verification will include available data from certified and/or flight-qualified aircraft components and data generated during the course of the ACT program.

W93-70038 (23) 510-02
Langley Research Center, Hampton, VA.

ADVANCED COMPOSITE MATERIALS TECHNOLOGY
C. P. Blankenship 804-864-6005

The objective of this research is to conduct advanced concept development, analysis, fabrication, testing, and demonstration programs in composite structures and materials with emphasis on primary structures for aircraft applications. The benefits of advanced composites will be exploited to develop enabling technology and the required scientific basis for verified innovative lightweight, structurally efficient, damage-tolerant, and cost-effective materials and structural concepts. Innovative concepts will be developed and demonstrated for use in future primary aircraft structures. A multidisciplinary approach will be utilized involving advanced organic composite 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. This work is expected to provide advanced composite materials and structures technologies for use by the U.S. aircraft industry to maintain international competitiveness.
The objective of this program is to advance rotorcraft systems technology for reduced noise and for advanced rotorcraft to enable advances in military and civil vehicles. A focused, integrated systems technology effort in acoustics and advanced configuration technology is necessary to regain U.S. preeminence in rotorcraft technology. Noise remains as one of the most persistent problems of conventional rotorcraft, limiting their effectiveness in civil and military applications. High subsonic speeds are needed to increase productivity and optimize effectiveness. Innovative low noise rotor technology will be developed by the acquisition of a modern airloads data base, refinement of predictive methods, and analytical and experimental investigations of innovative propeller designs. 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 advanced rotorcraft with special emphasis on tiltrotor configurations. Technology requirements for civil applications of the tiltrotor will be assessed. Operational, man/machine integration, and guidance and control issues including steep approaches and noise abatement profiles for civil tiltrotors will be investigated through simulation and flight test.

High-Performance Aircraft Systems Technology

W93-70041 (21) 533-02
Ames Research Center, Moffett Field, CA.

HIGH-PERFORMANCE FLIGHT RESEARCH
C. R. Jarvis 805-258-3177

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 will be completed with publication of final reports. Final analysis and reporting of the results of the flight phase of the Supersonic Laminar Flow experiment on F-16 XL Ship 1 was 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.

W93-70044 (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 ducted propeller technologies critical to the noise reduction of future Ultra High Bypass engines while achieving high efficiency and reliability. Noise prediction codes are developed and low noise cycles/concepts are experimentally evaluated in scale model wind tunnel tests which measure acoustic, aerodynamic, and structural performance. The technology developed is required by U.S. engine and airframe manufacturers in order to meet increased international/national noise rule stringency before the end of the decade.
The objective of this research is to develop the aerodynamic and acoustics technologies necessary for the design of high performance 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. Aerodynamic research emphasis is on improved methodologies for achieving optimum airframe-propulsion integration. Acoustics research emphasizes methodologies to predict and control noise from the large ducted fan propulsion systems. 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/ducted fan propellers, ducted fans, and aircraft configurations. The customers for this research include the U.S. aircraft engine manufacturers and the U.S. commercial transport aircraft companies. In addition, the FAA is a customer for this technology area in addressing community and airport noise issues.

W93-70046
Lewis Research Center, Cleveland, OH.

GA/COMMUTER ENGINE TECHNOLOGY
J. A. Ziemianski 216-433-3901

The objective of this effort is to provide the advanced technology base needed to insure the technical advantages of U.S. manufacturers in the future small 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. This research is aimed toward supplying the required analytical tools and engine sub-component technologies required for advanced rotorcraft (military and civilian), cruise missiles, general aviation, and commuter craft. In addition, the technologies are applicable to large engines, especially those incorporating high pressure ratios where size and boundary layer problems are accentuated.

Numerical Aerodynamic Simulation

W93-70047
Ames Research Center, Moffett Field, CA.

NUMERICAL AERODYNAMIC SIMULATION (NAS)
D. Cooper 415-604-4500

NASA created the Numerical Aerodynamic Simulation (NAS) Program in 1985 to provide a full-service, state-of-the-art supercomputing facility for the national aeronautics and aerospace communities as well as to serve as a pathfinder for the development of future supercomputing systems. The NAS Program is at the forefront of an effort to develop supercomputing systems 1000 times faster than those of today and to integrate their use with ever-more-powerful mass storage systems, networks, and high performance workstations. The NAS vision is to use these powerful systems to provide by the year 2000 the nation's aerospace research and development community with the resources necessary to simulate an entire aerospace vehicle in one-to-several hours. Efforts will include expanding the state-of-the-art of computational fluid dynamics to evolve to computational aeronautics applications. The NAS Program supports more than 1500 researchers and 350 projects across the nation— at the NASA Office of Aeronautics and Space Technology (OAST), other NASA centers and government agencies, in DoD, in industry, and in academia. Scientists have access to a complete supercomputing system that is upgraded regularly with a minimum impact on its use, together with a mass storage system; a nationwide system of high-speed networks; high performance graphics workstations; and an ever-increasing inventory of applications software. 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.

W93-70048
Ames Research Center, Moffett Field, CA.

NAS OPERATIONS
D. Cooper 415-604-4500

The objective is to assess the atmospheric effects of a fleet of High-Speed Civil Transport (HSCT) aircraft and establish system studies to provide an independent evaluation, through conceptual design and tradeoff studies, of the technology developments that can provide a more environmentally acceptable and economically viable high-speed civil transport aircraft. Also, to provide brief investigations of technologies and/or concepts, such as those associated with 'what if?' type technical questions. Issues include potential depletion of stratospheric ozone, perturbations to atmospheric chemistry on a global scale, and the potential for long term climate change. The approach is to conduct a program of theoretical and experimental research including laboratory measurements and modeling of the chemical processes in the lower stratosphere; to develop new instrumentation for the measurement of stratospheric gases using existing platform aircraft; and, as required, to support the development of unique new high
altitude platform aircraft. An Ames-developed aircraft synthesis program, ACSYNT, including an economic analysis module, is being used to investigate the inter-disciplinary design issues associated with high-speed transport aircraft. The synthesis code will continue to be enhanced, where appropriate, to enable the analysis of propulsion/airframe integration concerns, community noise, cruise altitude/emission effects, and sonic boom characteristics on economic viability. The economic analysis includes vehicle cost, total operating cost, and revenue requirements for a typical airline system. Tradeoff and sensitivity studies will indicate optimal parameter values, the benefits of technology improvements, and guide the formulation of research and technology plans. These results will be compared with contractor results and normalized to adjust for differing assumptions.

W93-70050 (10) 537-01
National Aeronautics and Space Administration, Washington, DC.

AMPHOSPERIC EFFECTS
Louis J. Williams 202-453-2828
(537-02-00, 537-03-00)
The objective of this RTOP is to carry out critical analysis and review of past and ongoing research relevant to the Atmospheric Effects of Stratospheric Aircraft and Low Emissions Combustor Technology elements of NASA's High-Speed Research Program (HSRP). A task will be procured under an existing DoD contract with the Institute for Defense Analyses. Specific topics, to be assigned by the NASA Program Manager, shall be addressed by the Contractor to a depth consistent with the scope of resources.

W93-70051 (22) 537-01
Lewis Research Center, Cleveland, OH.

AMPHOSPERIC EFFECTS
L. H. Fishbach 216-977-7020
Studies will be conducted to identify the most promising engine and noise suppression concepts/technologies for a High-Speed Civil Transport (HSCT) and the economic penalties associated with satisfying projected environmental constraints. A spectrum of propulsion system concepts and technologies will be investigated in sufficient depth to identify preferred engine types and optimum cycle parameters to minimize the adverse effects of complying with expected airport noise and cruise emission constraints. Key technology needs will be identified as well as the associated benefits. After preliminary screening analyses by the engine companies and NASA, airframe manufacturers will perform a final assessment via a flyoff analysis to help downselect to two inlet/engine/nozzle systems. This work is expected to result in the identification of the HSCT engine and noise suppression concepts for the U.S. aeronautical industry that will satisfy projected environmental constraints with minimum economic impact.

W93-70052 (23) 537-01
Langley Research Center, Hampton, VA.

AMPHOSPERIC EFFECTS
Roy V. Harris, Jr. 804-864-6048
The objective of this RTOP is to provide guidance and direction to aeronautics/proposal research and technical programs by NASA and the U.S. aviation industry to assure that any future fleet of High-Speed Civil Transports (HSCT's) would not have a detrimental effect on the Earth's atmosphere. The best available atmospheric models will be used and improved to assess the effect of a projected fleet of HSCT's on global ozone, stratospheric climatology, and the stratospheric-tropospheric radiative balance. An oversight panel of experts in the field will review the research which can ultimately provide guidance for an acceptable emissions budget and/or flight altitudes. Aircraft system studies will be conducted to determine the viability of technological solutions for environmental concerns and to identify high pay-off technology developments that will lead to an economically viable and environmentally acceptable HSCT. This research is expected to result in advanced technology for future application by industry in developing a High-Speed Civil Transport.

W93-70053 (21) 537-02
Ames Research Center, Moffett Field, CA.

EMISSIONS AND SOURCE NOISE
R. Kurkowski 415-604-6569
Three areas relating to the High Speed Civil Transport (HSCT) are addressed: low emission combustion, jet noise reduction, and nacelle airframe integration. The objectives for these three areas are the following: to develop NO(x) control technologies such that NO(x) production levels will be in the 3 to 8 g/kg (emission index range); to develop high-speed jet noise reduction technology and concepts which would allow future HSCT's to comply with FAR Part 36 Stage 3 noise levels; and to investigate the acoustical, internal performance, and stability characteristics of candidate inlet systems, and propulsion airframe integration for HSCT aircraft. The approach for combustion analyses includes the development and use of advanced computation methods and codes to model the reacting turbulent flow in candidate combustor configurations. Emphasis will be given to the computational chemistry determination of the chemical kinetics. The approach to reduce high-speed jet noise will be to develop and verify advanced aerodynamic analyses and noise prediction capabilities through higher-fidelity computational models and controlled laboratory experiments using the 40 x 60 foot wind tunnel and advanced flowfield and noise measurements. Also, working with other centers and industry, the approach is to develop and conduct a CFD analysis and experimental program using the Ames Unitary Plan Wind Tunnel (UPWT) (9 x 7, 11 x 11) to study nacelle airframe integration, inlet stability, inlet acoustics, and nacelle effects on sonic boom.

W93-70054 (22) 537-02
Lewis Research Center, Cleveland, OH.

EMISSIONS AND SOURCE NOISE
E. J. Graber 216-433-5900
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 3 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 a test of prototype combustor configurations to demonstrate acceptable NO(x) emissions levels and combustor efficiency. The work is focused on the development of a propulsion system technology base to provide industry with the information to make an informed 'go/no go' decision on a second generation supersonic transport.

W93-70055 (23) 537-02
Langley Research Center, Hampton, VA.

EMISSIONS AND SOURCE NOISE
C. P. Blankenship 804-864-6005
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 to develop technology to support an economically viable transport compliant with Federal Air Regulation 36 Stage 3. Improved understanding of the physical mechanisms by which supersonic flows generate noise is also sought along with the development of theories and validated data bases for accurate noise prediction and reduction. Analytical, computational, and experimental approaches are included in the research which is conducted in-house, by university grants, and with industry contracts. The experimental portion of the program emphasizes model scale laboratory studies under controlled conditions. The customers for this research include U.S. aircraft engine manufacturers and the U.S. commercial transport.
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

aircraft industry. In addition, the FAA is a customer for this technology area in addressing community and airport noise issues.

W93-70056
(21) 537-03
Ames Research Center, Moffett Field, CA.
COMMUNITY NOISE AND SONIC BOOM
R. Kurkowski 415-604-6569
The objectives are to develop the design methodology for a High Speed Civil Transport (HSCT) in order to accomplish the following: (1) reduce community noise (i.e. takeoff and approach noise) to Federal Aviation Regulation (FAR) 36 Stage 3 levels; and (2) minimize the sonic boom impact. In a supersonic 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 associated fuel requirements, emissions, and noise. Community noise reduction involves the development of accurate system noise prediction methodologies for HSCT's, optimized engine placement for minimum noise impact, and efficient, low-speed, high-lift systems.

W93-70057
(23) 537-03
Langley Research Center, Hampton, VA.
COMMUNITY NOISE AND SONIC BOOM
Roy V. Harris, Jr. 804-864-6048
The objective of this RTOP is 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 Federal Aviation Regulation (FAR) 36 Stage 3 noise rules to be allowed to take off and land at existing international airports. Meeting community noise rules will most likely impose the severest weight and efficiency penalties of the environmental concerns. Validated noise prediction and suppressor technology will be developed as well as improved high-lift systems to enable flight path optimization. Sonic boom prediction, propagation, minimization, and human perception must be better understood. A flight experiment and accompanying transition prediction and design methodology will develop and validate technology for practical, reliable, and maintainable supersonic laminar flow concepts. This research is expected to result in advanced technology for future application by industry in developing a High-Speed Civil Transport.

W93-70058
(22) 537-04
Lewis Research Center, Cleveland, OH.
ENABLING PROPULSION MATERIALS
J. R. Stephens 216-433-3195
The objective of this RTOP is, in cooperation with U.S. industry, to develop and demonstrate by 1999 the technical feasibility of high temperature, lightweight composites for critical components of gas turbine engines, so that a high speed civil transport (HSCT) may be introduced into service by the year 2005. To accomplish this objective, a major contractual effort, augmented by in-house research, will be undertaken over a seven-year period. Major emphasis will be on two engine components: the combustor and the exhaust nozzle. Research and development will focus on ceramic matrix composites for the combustor and intermetallic, metal, and ceramic matrix composites for the nozzle. Long-term durability at extremely high temperatures will require research on the following: fibers and fiber coatings; environmental durability; life prediction; failure analysis; composite fabrication; and joining technology. Component design-material property trade-off studies will guide the research and development efforts. This work is intended to provide the necessary technology so that the U.S. jet engine manufacturers can make a favorable decision to proceed with development of engines for the HSCT.

Advanced Subsonic Technology

W93-70059
(22) 538-01
Lewis Research Center, Cleveland, OH.
FLY-BY-LIGHT/POWER-BY-WIRE TECHNOLOGY
Gary T. Seng 216-433-3732
The overall objective of the program is to develop the technology base necessary for the confident application of integrated fly-by-light (FLB) and power-by-wire (PBW) systems to transport aircraft. Fly-by-light propulsion/flight control system technology will be advanced through research in electro-optic architectures and fiber optic sensors. The systems developed will be demonstrated through active (closed loop) ground and flight tests. Power-by-wire technology research will focus on the development of an integral starter/generator, an advanced power management and distribution system, and electromechanical actuators (EMA). The full system will be ground tested and the EMA's flight demonstrated as an integral part of the active control system.

W93-70060
(23) 538-01
Langley Research Center, Hampton, VA.
FLY-BY-LIGHT/POWER-BY-WIRE
J. F. Creedon 804-864-6033
The objective of this RTOP is to develop the technology base for confident application of integrated Fly-By-Light/Power-By-Wire (FLB/PBW) systems to transport aircraft. This is a joint LaRC and LeRC program. LeRC objectives are to develop and flight test the following: optical sensors and electro-optical converters, power management and distribution system; and electromechanical actuators. LaRC objectives are as follows: (1) to demonstrate architecture design and validation appropriate for certification of FLB/PBW systems; (2) to develop validated analytical and experimental assessment methodologies for electromagnetic interference (EMI) effects; and (3) to integrate/demonstrate end-to-end FLB/PBW systems in ground and flight tests. The approach of this RTOP will be to do the following: (1) devise, analyze, develop, fabricate, and test an optically based FLB/PBW architecture consisting of redundant optical sensors, fault-tolerant fiber-optic signaling, fault-tolerant computers, and a secondary power management and distribution system; (2) determine system level requirements, synthesize an architecture meeting the requirements, and validate that the architecture meets the requirements by applying design for validation concepts throughout the design process; (3) devise analytic and laboratory upset test schemes for EMI; and (4) assimilate and integrate technologies developed in other program elements, configure an evaluation system, and perform ground and flight tests. The full benefits of full authority digital control of transport aircraft have not yet been realized for U.S. aircraft. The intrinsic EMI immunity of optics technology can significantly enhance acceptance of full authority digital control by circumventing EMI concerns associated with Fly-By-Wire (FBW), and provide lifetime immunity to signal EMI. Additionally, FBL has the potential to greatly simplify certification against EMI by enabling bench tests of subsystems, as opposed to full airplane systems tests which are currently required to account for the interaction of EMI threats such as High Intensity Radiated Fields (HIRF) with wire based signal transmission media.
The primary objective of the aging aircraft program is to provide the technology that will enhance the structural integrity of commercial aircraft. The specific research objectives are as follows: (1) to develop and verify advanced nondestructive evaluation (NDE) technology that can reliably and economically detect disbonds, fatigue cracks, and corrosion of airframe structures; and (2) to develop and verify advanced mechanics-based prediction methods which can be used to determine in-service inspection intervals, quantitatively evaluate inspection findings, and design and certify structural repairs. In addition, fuselage structural analysis methods will be developed and validated to assess overall structural integrity in the presence of fatigue damage. These research objectives will be accomplished through combined in-house, contract, and grant activity. To facilitate technology transfer, the program will be conducted in full cooperation with the U.S. airframe manufacturers and airline operators. The customers for this technology area include the U.S. transport aircraft manufacturers and commercial airline operators. In addition, the FAA and DOT are customers for these technologies in conducting their mission responsibilities.

Aging Aircraft

Space Research and Technology Base

Aerothermodynamics Research and Technology

AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY

W 93-70062
Ames Research Center, Moffett Field, CA.

This study is to advance the fundamental understanding of aerodynamic flows in hypersonic flight regimes and to develop codes to perform optimization of future aerospace vehicles. Advanced computational methods and computer codes will be developed and validated for numerically simulating vehicle flow fields and then used to predict the 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. 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. 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, hyper-velocity flows. Research for future experimental ground based facilities to study real-gas hypersonic flows will be conducted. A candidate for study is an arc-driven hypersonic wind tunnel.

Space Energy Conversion Research and Technology

AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY

W 93-70063
Langley Research Center, Hampton, VA.

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 placed 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 convective 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. 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 computational program requires extensive use of current super computers and parallel computers and utilization of future computer technology. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. The technology developed is used by NASA organizations, other government agencies, industry, and universities in the evaluation and design of improved or new aerospace vehicles.

W 93-70064
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. Both generic and NASA specific 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 of study 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 Low Earth Orbit (LEO), Geosynchronous Earth Orbit (GEO) and planetary environments. Advanced space power is a critical, enabling technology essential for the success of a wide range of NASA and other user applications. The above program provides key technologies for advanced LEO and GEO Space Platforms, Space Science Missions, lunar and Mars bases, planetary rovers, deep space platforms, and space transportation systems. Because all relevant technological approaches have their range of applicability and their limitations, it is essential that a broad range of robust options be pursued. Thus the work must span applications from subkilowatt to megawatts, static to dynamic with some being sun-independent. The multiple mission applicability of these technologies and the significant synergism that emerges during development thus leads to major Agency benefit.
The principal objective of this research is to develop, analyze, and test advanced thermal energy management concepts and components for future spacecraft and space facilities. The primary application is for the thermal control of instrumentation, sensors, and other heat dissipating equipment. Low to room temperature long life applications will be stressed. Current focus is on such two-phase thermal control devices as cryogenic heat pipes and modular, space qualified heat pumps. These technologies have been identified as necessary to enhance and/or enable future missions. 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; (3) development of analytical models and correlation to test data; and (4) small flight experiments. Thermal Energy Management involves the acquisition, transport, rejection, and (possibly) storage of heat. The thermal system is a basic utility which provides an essential service to other spacecraft systems such as power, communication, sensors, and propulsion. Effective accomplishment of the above objectives requires an organized approach involving systems level analysis, experimentation, and model development. The approach is to first evaluate proposed future missions to identify new technology needs, and then conceive, develop, and demonstrate appropriate solutions. Hardware development begins with laboratory breadboards, and successful concepts are carried to the brassboard level. Analytical models are developed in concert with the hardware, and correlated to test data (as available) for validation. At this point potential customers (such as flight projects) are brought into the effort as it transitions from generic research to application specific development. At this point the project will assume support for the effort.

The objective is to develop and demonstrate advanced technologies in the areas of power switching and control, chemical energy conversion, photovoltaic energy conversion, and thermal energy conversion for planetary spacecraft, rover, and probe power systems. The principal goal is to develop power technologies that minimize power system mass, volume and parts count, and enable small (mini) spacecraft systems. Also, we seek to meet the power requirements of future missions that may also include minirovers, penetrators, and operation in harsh (low and high temperature, high pressure) environments. The first goal is to advance power switching and control functions from discrete to monolithic technologies leading to increases in power density from 1W in (exp 3) to more than 10W in (exp 3), and 60 percent reduction in parts count, and the capability to integrate digital electronics and analog power functions in monolithic packages. The second goal is to develop and demonstrate high efficiency photovoltaic array technology that produces nearly 300 W/kg and 300 W sq m for earth orbital, planetary (to 5 A.U.), and electric propulsion missions. The third goal is to develop high cycle life, 100 W-hr/kg rechargeable batteries, including thin film rechargeable cells, and develop thermal-to-electric conversion technologies capable of efficiencies of at least 10 percent (thermoelectrics) or 20 percent alkali metal thermoelectric converter (AMTEC) that would enable small, high performance, modular (mini), radioisotope power sources. The approach includes industry tasks for prototype demonstration. These goals are approached by: (1) developing solar cells for deep space applications by developing a method to prevent low intensity, low temperature degradation through electrical and radiation characterization of new, high performance cells; (2) developing ambient temperature lithium rechargeable cells capable of delivering at least 100 W-hr/kg and 1000 cycles at 50 percent state of charge, having an active shelf life of five years; (3) demonstrating efficiency and lifetime performance in AMTEC recirculating cells through thermal design optimization, current collection optimization and component lifetime improvements, to determine the feasibility of silicones as high performance thermoelectric materials; and (4) developing synchronous rectifier prototype hybrids to test and evaluate smart-pole hybrid prototypes, and test and evaluate opto-coupler hybrids.

The objective is to provide propulsion technology, including cryogenic fluid management, for future Earth-to-Orbit vehicles, 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. Base R&T products are structured to have broad utility for a range of applications and customers. Customers include the mission centers and development centers of NASA, as well as the DOD and commercial launch services industry. Base R&T tasks are directed at critical issues across a broad spectrum of propulsion concepts as they apply to on-board, upperstage, transfer stage and Earth-to-Orbit propulsion systems and to cryogenic fluid management systems. The low thrust on-board propulsion arena includes both electric and chemical systems. Advances in diagnostics, modeling, materials and design methodologies are expected to result in a broad range of applications in the government and commercial earth orbiting platform, spacecraft and launch and transfer vehicle industries. The high thrust propulsion includes a range of propellant combinations and thrust sizes. Advances in understanding and modeling of critical combustion and turbomachinery processes, systems and health management systems is expected to result in application to future upperstage, transfer and launch systems. The cryogenic fluid management includes long term storage, pressurization, mass gaging and 1-g fluid transfer. Advances in these critical technologies are expected to result in application to cryogenic vehicles, in-space storage and lunar/planetary storage systems.
Materials and Structures Research and Technology

Office of Aeronautics and Space Technology

W93-70071 (21) 506-43

Ames Research Center, Moffett Field, CA.

The objective is to provide advanced materials technology for future space systems with significant improvements in performance, durability, and economy. Emphasis is given to computational materials science and thermal protection materials.

In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These computations, and extrapolations to larger systems, are being compared with experiments to obtain surface and bulk properties. Ames’ unique arc jet facilities, ceramic and metallic materials laboratory, and analytical and computational capabilities are used to develop next generation materials and optimized thermal protection systems for advanced space transportation vehicles, enhanced Space Shuttle vehicles, aerostressed space transfer vehicles (ASTV), planetary and solar probes, and the safe earth entry of vehicles utilizing radioactive power sources. Candidate thermal protection system concepts and materials are subject to systematic development, analysis, and testing. Arc jet research conducted in this activity will assure that NASA materials characterization continues to be accomplished in state-of-the-art test facilities. Results from computational chemistry are used to study chemisorption, catalysis, corrosion, and the physical properties of polymers. Results from the material development, testing, and computational research activities are transferred to scientists and engineers working on Agency programs for entry technology (ASTV’s, TAV’s and probes), for the characterization of spacecraft materials for use in low-earth orbit, and the development of advanced ceramics, ceramic matrix composites (CMC’s), and polymers for aerospace applications. These scientists and engineers represent our ‘customers’ and are employed by user field centers, other government agencies, aerospace industry, and academia. The objective is also to design, analyze, fabricate, and test a generic research cryogenic tank (GRCT), and to develop techniques and measurement systems, and the materials and structures technology needed by industry for significant improvements in the performance, durability, and economy of future generation cryogenic tankage for spacecraft.

W93-70072 (10) 506-43

National Aeronautics and Space Administration, Washington, DC.

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.

W93-70073 (22) 506-43

Lewis Research Center, Cleveland, OH.

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 improved aerospace materials. The research includes: (1) material properties/performance enhancement via innovative applications 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) exploration of new materials for heat storage and space power applications; and (4) 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
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

dependencies of well characterized materials exposed to specific simulated low earth orbital environments. This work is expected to result in advanced materials systems for future application in advanced space power and propulsion systems.

W93-70074 (23) 506-43
Langley Research Center, Hampton, VA.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005

The objective of this research is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Spacecraft research emphasis is placed on (1) development of advanced polymeric, composite, and metallic materials that can be tailored to provide improved spacecraft performance; (2) development of concepts for automation of on-orbit construction of spacecraft; (3) development of analytical methods for prediction and control of spacecraft dynamics; and (4) development of interdisciplinary analysis and optimization methods for spacecraft design. Research in space transportation systems (STS) emphasizes (1) analytical and experimental verification of aerothermal structural loads; (2) thermal structures concepts and analysis methods; and (3) development of advanced metallic and composite materials for both cryogenic and high temperature applications. The approach uses analytical, computational, and experimental methods in fundamental research that is conducted in-house, by university grant, and under contract to industry. The customers for this research include U.S. spacecraft and space transportation manufacturers. In addition, the NASA development Centers are customers for this technology area in performance of their flight missions.

W93-70075 (55) 506-43
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. Moacanin 818-354-3178

The overall goal is to develop materials and structures technologies required for analysis, design, fabrication, characterization and control of long-life precision space structures and space optical systems, in order to enable or enhance future NASA missions in astrophysics, earth observing systems, and optical communications. Systems of interest include reflectors, antennas, optical benches, interferometers, advanced planetary cameras, and telescopes.

W93-70076 (62) 506-43
Marshall Space Flight Center, Huntsville, AL.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-1762

The Long Duration Exposure Facility (LDEF) effort under this RTOP consists of two tasks. The first task is the continuation of the evaluation of LDEF experiments A0034, S0069, and A0171. These experiments all provided samples of materials that have been exposed to the environment of space for an extended period of time (5.8 years). Specialized analyses are required on the samples obtained. These analyses have direct applicability to Space Station, Advanced X-ray Astrophysics Facility (AXAF), Space Exploration Initiative (SEI) and materials usage in space in general. The second LDEF task in this RTOP supports the LDEF Ionizing Radiation Special Investigation Group (IRSIG). The principal objective of the IRSIG is to use LDEF data to rigorously test the accuracy of present models and methods for predicting ambient environment particle fluences and spectra, dose linear energy transfer spectra, secondary particles such as neutrons and recoils, and some radiation effects. The IRSIG program will also test a new model of trapped protons that includes directional effects. Extensive calculations using currently accepted and new models will be compared to the measurements. Full assessment of the accuracy of current and proposed calculation methods will be documented and disseminated. Methods and materials will be archived. The objective of the Hydrogen Environment Embrittlement (HEE) resistant alloy development program is to improve the mechanical properties of NASA-23 and JBK-75 alloys in high pressure hydrogen by modifying their composition. Initial effort will focus on testing to verify an existing hypothesis in which the HEE resistance of an alloy is inversely related to the matrix electron/atom (e/a) ratio. Following this, the composition of NASA-23 will be modified to improve the HEE resistance while preserving its strength. The strength of JBK-75 will be improved in two steps: the first step will increase the volume fraction of gamma prime; the second step will increase the molybdenum and tungsten content of the alloy to enhance the strength of gamma matrix. These results will be achieved without sacrificing the good HEE resistance of JBK-75. Castability of the alloys will be demonstrated using standard casting shapes. A material property data base will be generated for both alloys. Advanced propulsion systems will benefit from the use of these alloys.

W93-70077 (72) 506-43
Lyndon B. Johnson Space Center, Houston, TX.

MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. L. Koontz 713-483-5906

(1) The objective of the oxygen effects on materials task is to develop a sound understanding of atomic oxygen and solar ultraviolet/visible ultraviolet (UV/VUV) effects on spacecraft materials so that ground based test methods can be evaluated and materials selection for NASA and DOD spacecraft can be made with confidence. The approach is to develop an accurate laboratory simulation of the low-earth orbit environment in the high velocity neutral atom beam at Los Alamos National Laboratories as well as a well characterized thermal atom test system at JSC. Materials reactivities produced in these two systems (some under accelerated test conditions) are compared with reactivities produced in several NASA flight experiments. Flight instruments supporting NASA and DOD missions in LEO are calibrated at the Los Alamos Facility. (2) The objective of the hypervelocity impact task is to develop an improved understanding of hypervelocity impact phenomena so that improved armor can be developed with confidence. Sophisticated high-speed camera systems record the details of hypervelocity impact events for comparison with hypervelocity impact hydrocodes. Validated hydrocodes are used to design improved armor. (3) The objective of the LDEF studies task is to obtain the maximum data yield possible from the LDEF samples held by JSC. Optical scanning of space exposed surfaces, classification of impact events and modeling of the orbital micrometeoroid and debris environment are done along with curation of LDEF materials.

Space Flight Research and Technology

W93-70078 (22) 506-48
Lewis Research Center, Cleveland, OH.

SPACE FLIGHT RESEARCH AND TECHNOLOGY
O. D. Gonzalez-Sanabria 216-433-5252

To define and develop NASA space technology experiments for the evaluation and validation of advanced space technologies being developed at the Lewis Research Center, LeRC is currently managing two flight projects on the power systems technology theme: Solar Array Module Plasma Interaction Experiment (SAMPLE) and Thermal Energy Storage (TES). SAMPLE will develop a space experiment to determine the environmental effects of the Low Earth Orbit (LEO) space plasma environment on the state-of-the-art solar modules biased to high potentials relative to the plasma. The experiment will fly as part of the OAST-2 mission, scheduled for the 2nd quarter of FY-94. This work will provide the data needed to validate the NASCAP/LEO modeling program.
used for spacecraft power system analysis and design. TES will
develop and fly an experiment to characterize void shape and
location in phase change materials (PCM) used in a thermal energy
storage canister configuration representative of solar dynamic
power system design. Four experiments are planned with different
combinations of PCM, geometries, and wettability. The first two
experiments, TES-1 and TES-2, are scheduled to fly as part of
the OAST-2 mission scheduled to the 2nd quarter of FY-94.
This experiment will provide data leading to higher thermal
efficiency and increased reliability of performance for future heat
receiver designs.

W93-70079
Langley Research Center, Hampton, VA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
F. Allario 804-864-8027
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 (1) to 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; and (2) to 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 impact of the orbital environment on instrument performance
for future space users.

W93-70080
Goddard Space Flight Center, Greenbelt, MD.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. McIntosh 301-286-3478
There are three primary objectives for this RTOP. The first is
to provide for the integration of the five experiments manifested
for launch as part of the OAST-2 mission scheduled for February,
1994. These experiments include the Thermal Energy Storage
Experiment (TES), Experimental Investigation of Spacecraft Glow
(EIGS), the Emulsion Chamber Technology Experiment (ECT), the
Solar Array Module Plasma Interaction Experiment (SAMPLE),
and the Spacecraft Kinetic Infrared Test (SKIRT). The integration
activities include thermal design, safety, mission operations, design,
fabrication and qualification of unique hardware required for this
set of experiments and development of analytical models. The Hitchhiker Project also advises and assists the experimenters in
developing solutions for unique problems and in developing
documentation and in interfacing with the NASA Space Shuttle
System. The data obtained from these experiments benefit a broad
range of future flight programs. The second part of this RTOP
provides for the integration of the OAST Flyer mission manifested
for mid 1995. This flight will make use of the SPARTAN carrier
which will be deployed from the Shuttle bay for approximately
forty hours as a free flyer. The integration activities include design
and development of unique hardware, development of mechanical
and thermal analytical models, development of safety and mission
related documentation and development of mission scenarios. In
addition, the SPARTAN Project will provide assistance to the
experimenters in solving mission related interfacing and
documentation problems. For this flight the SPARTAN will carry
the Return Flux Experiment (REFLEX) and at least one other
instrument. The third element of this RTOP involves the
development of the REFLEX experiment. This experiment is
designed to investigate the molecular contamination returned when
material is outgassed from a spacecraft or instrument. The REFLEX
will carry a magnetic sector mass spectrometer which has the
capability to quantify the velocity, specie and density distribution
of molecules passing through its entrance aperture. Two gases
(neon and krypton) will be expelled from the REFLEX at known
rates, and the mass spectrometer will measure how much of the
gas returns to the experiment via scattering from collisions with
itself or the ambient environment. The experiment will also measure
the effect of ambient atomic oxygen on materials deposited on
quartz crystal microbalances prior to launch. The data obtained
from this experiment will be used to validate our analytical models
for contamination. Therefore, the data from this experiment will
benefit many future flight programs.

W93-70081
Lyndon B. Johnson Space Center, Houston, TX.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. L. Giesecke 713-283-5420
The objectives of the Orbiter Experiments (OEX) program are
to collect data in the technology disciplines that will augment the
research and technology base for future spacecraft design. Flight
data relative to these disciplines will be collected by the
development of unique experiments compatible with the flight
operational capabilities of the Orbiter. The approach entails the
following: (1) provide overall project and technical management,
integration and support; and (2) conduct compatibility assessments
for integration. During FY-93, it is anticipated that JSC will not be
involved in new proposal evaluation activities in support of OAST.
However, JSC will continue to provide support to OAST in the
assessment of selected In-Step proposals as required.

W93-70082
National Aeronautics and Space Administration, Washington, DC.
SYSTEMS ANALYSIS
Gregory Reck, M. 202-453-2733
The objective of this RTOP is to provide space program studies
in support of OAST space technology program requirements,
assessments, planning, and advocacy. The studies are intended
to provide an analytical basis for planning activities in space
research and technology. Areas of work will include: technology
status and trends assessments; mission concepts and systems;
long-range planning activities; and 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 OAST in space research and technology.

W93-70083
Lewis Research Center, Cleveland, OH.
SYSTEM ANALYSIS
O. D. Gonzalez-Sanabria 216-433-5252
The objective of this RTOP is to compare and evaluate various
advanced propulsion system technologies that would best satisfy
transportation requirements for a variety of future NASA missions.
These advanced technologies would include high and low thrust
systems utilizing chemical, solar and nuclear energy sources. These
studies would include assessment and evaluation of the advanced
propulsion technologies themselves as well as an evaluation of
cryogenic technologies and requirements for these advanced
propulsion systems. Studies would be performed primarily with an
in-house core of existing civil service and support service
contractors. Studies would evaluate advanced component
technologies in complete propulsion system concepts. Mission
design and analyses will be performed to assess the technologies
from an overall mission perspective. Selected subtasks will be
performed through an existing task order contract. System and
mission analyses computer code capability used to evaluate
technologies will be enhanced using in-house, university, and
contractor expertise.
The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support the design and development of future spacecraft, advanced Earth- and space-based transportation vehicles, lunar and planetary transportation systems and space platforms and space stations via system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational 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. The results of this research will be utilized to focus technology and advanced development resources in the most effective areas to enhance future civil and military space missions. Conceptual design, systems analysis, and comparative assessment trade studies allow orderly and systematic identification of technology needs and benefits.

The objective is to identify and prioritize technology needs for future astrophysics, solar system exploration, earth sciences, life sciences and space physics missions; to identify and prioritize multi-mission technology needs in such areas as information systems, spacecraft subsystems, flight control and operations and ground test and processing; to evaluate the applicability of emerging technologies to NASA missions; and to provide development plans for high priority technologies. Selected advanced mission and instrument concept studies will be conducted jointly with Code S to ensure participation of both the user and the technology communities and the consideration of a broad range of technology options. Workshops will be held to facilitate the exchange of ideas and lay the foundations for technology development plans.

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

The objective is to conduct fundamental research in telerobotic space operations, including the development of a wide range of analytic tools and experimental techniques for use in space operations research with particular emphasis on telerobots development. This will be augmented by further study of zero-G anthropometrics, automation, robotics, and artificial intelligence applications. The task will be conducted at the University of Maryland.

The objective is to achieve innovative advances in information acquisition, understanding, and processing by integrating the research efforts in sensors, artificial intelligence (AI), robotics, advanced data architectures, photonics, and human factors engineering. Research is focused towards increased science and engineering productivity through the use of advanced information systems concepts with lower costs, and no compromise to mission safety. The approach in sensors research is to utilize and characterize, through extensive in-house, low-background testing, recent developments in materials such as improved semiconductors and recent advancements in layered devices such as impurity band conduction detectors to achieve advanced detectors for astronomy. The approach in AI research is to integrate fundamental concepts in machine learning, pattern recognition and classification, and large scale knowledge base technology into software tools for scientific data base analysis and model building, automatic of diagnosis and scheduling systems, and software analysis and reusability leveraging DARPA technology where feasible. The approach in robotics research is to evaluate integrated knowledge-based systems for mobile intelligent space robotics systems through demonstrations at Stanford University's Aerospace Robotics Laboratory. The approach in advanced data systems research is to evaluate adaptive neural networks capable of recognizing sensor patterns indicative of impending engine and structural failures using information from distributed sensor arrays, and to integrate concepts into an adaptive reconfigurable controller. The approach in photonics research is to develop a world-class in-house team/environment in collaboration with industry, academia, and other Government agencies, e.g., DARPA, and to conduct extensive in-house demonstrations of new optical technologies to achieve at least an order of magnitude improvement over equivalent digital processors in real-time image processing using advanced materials and devices such as fiber optic sensors, novel neuromorphic elements, and materials derived from biological sources. The approach in human factors research is to collaborate with operations centers in defining operational requirements and testing prototype systems leveraging extensive experience in aeronautical/defence systems through demonstrations at Stanford University's Aerospace Robotics Laboratory. The approach in advanced data systems research is to develop a world-class in-house team/environment in collaboration with industry, academia, and other Government agencies, e.g., DARPA, and to conduct extensive in-house demonstrations of new optical technologies to achieve at least an order of magnitude improvement over equivalent digital processors in real-time image processing using advanced materials and devices such as fiber optic sensors, novel neuromorphic elements, and materials derived from biological sources. The approach in human factors research is to collaborate with operations centers in defining operational requirements and testing prototype systems leveraging extensive experience in aeronautical/defence systems through demonstrations at Stanford University's Aerospace Robotics Laboratory.

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technology for advanced data and information processing systems and networks for space applications; development and laboratory testing of microwave remote sensor technology for geostationary and low Earth orbit applications; development of electromagnetic (EM) analysis methods for predicting the performance of large aperture systems; development and evaluation of advanced technology for space telerobotics applications; and investigation and laboratory implementation of advanced sensors and actuators for control of large space systems. The approach taken includes establishing basic concepts and theories; developing and validating new concepts and innovative techniques through analysis, simulation, and laboratory testing; and demonstration and transfer of technology of the most promising concepts through flight tests or technology bridging activities with a NASA development center or industry partner. Advanced GN&C, information and data processing, large space systems control, radiometer systems, telerobotics, and control sensors and actuators technology developed and evaluated under this RTOP provides new, innovative concepts for use in future NASA and industry space programs such as the National Launch System (NLS), Space Station Freedom (SSF), Mars and Lunar exploration/exploration, Earth Observing System (EOS), and Space Transportation System (STS). Novel concepts and validated technology from this RTOP are transferred to NASA development centers and industry users through workshops, technology bridging activities, cooperative agreements, publications and presentations, industry tours, as well as direct discussions initiated by either LaRC or the space technology user community. Primary customers are NASA development centers and program managers for Code R focussed programs and DOD/civilian space programs.

**W93-70090**

Goddard Space Flight Center, Greenbelt, MD.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

H. Plotkin 301-286-6185

The objectives of this RTOP are the following: to reduce burgeoning operational costs through knowledge-based automated software reuse, and develop an automated software management environment to monitor and improve software development efficiency and reliability; to develop systems to handle very large multi-source data bases managed at distributed locations; to apply expert systems to aid in extracting cumulative information in complex data bases; to develop an Intelligent Information Fusion System; to encode multi-spectral image data; to develop methodologies for uniformly accessing heterogeneous software repositories; to perform research on novel improved spaceborne detectors for cosmic-ray, x-ray, and infrared radiation; to develop cosmic ray spectrometers based on solid-state silicon strip detectors; to develop high spectral resolution x-ray detectors for astrophysics using low temperature superconducting absorbers and either tunnel junctions or microcalorimeters; and to develop thermal IR detectors, operating at 65K, for outer-planetary missions, employing composite-type infrared bolometers with high temperature superconducting thin films as the thermometer.

**W93-70091**

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

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

Richard Key 818-354-3060

This RTOP covers research in a diverse array of areas that are critical to future NASA space systems. The objective is to develop advanced technologies relevant to NASA applications in the areas of computer science, data systems, photonics, science sensors, control systems, robotics, and artificial intelligence, which will provide new capabilities and/or greater performance over the current state-of-the-art. Computer science research will demonstrate an easy to use and inexpensive cataloguing technique to facilitate software reuse and retrieval. A versatile tool named ‘HILITE’ is being developed to do this by integrating the technologies of hypermedia, graphical user interface, knowledge engineering, and object-oriented data base management. Data Systems work will develop application specific electronic neuroprocessor building blocks that will be used to demonstrate real-time functionality of neuroprocessing via a vehicle health monitoring application for the Space Shuttle Improved Auxiliary Power Unit. Photonics work will develop InP based optoelectronics integrated circuits (OEIC) for integrated optic spectrometers, fiber optic ring sensors, optical disk read/write heads, and integrated transmitter/receiver applications. Sensors research will develop unique wavelength semiconductor lasers for injection seeding of solid state lasers. Other research will produce high temperature superconducting devices with optimized microwave response properties for NASA applications such as advanced sensors and low-loss microwave components. Control research will produce several advanced technologies. New computational design tools will be developed to reduce the time and cost required to design and test spacecraft control systems. Advanced metrology concepts with nanometer level performance will be demonstrated for applications like optical space interferometers. An advanced star tracker concept will be developed for real-time autonomous spacecraft attitude determination. System identification and adaptive control research will develop techniques and software to enable automated monitoring of system performance and robust control system self-tuning, and autonomous compensation of dynamic uncertainties and/or spacecraft configuration changes. Robotics research will develop long range technologies in the areas of: automated surface inspection techniques to detect and classify flaws and monitor changes in space structures; complex telerobotics work events and conditions using special graphic displays; microversible navigation sensing and control strategies that can be applied to planetary exploration missions; and mobile robot architectures with low power requirements that provide real-time goal directed performance. Artificial Intelligence research will develop new technology in two areas. Selective monitoring work will achieve designs of AI-based systems to provide focus of attention and anomaly detection capabilities in support of mission operations performing real-time monitoring of space platforms. AI for software reuse work will develop techniques for searching, navigating, and database updating in hypermedia systems.

**W93-70092**

Lyndon B. Johnson Space Center, Houston, TX.

**INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY**

J. W. Sunkel 713-483-8591

The first objective is to develop and assess guidance, navigation, and control concepts, techniques, and design methodologies to provide needed capabilities for future 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 interfacing space elements including the Space Shuttle, Space Transfer Vehicle (STV), Manned Maneuvering Units (MMU), free-flyers, aeromaneuvering planetary and earth return vehicles, and the Space Station Freedom. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. The second objective is to develop redundant mechanism architectures and control strategies for robotic manipulator systems which incorporate the ability to transparently absorb drastic mechanism, sensor or control failures and maintain stable end-point trajectory control with minimum disturbance. The third objective is to develop and evaluate concepts and guidelines for designing informative, reliable and usable intelligent systems to support human tasks in real-time operations. This element is providing a series of interim products to guide the design of intelligent support systems and their user interfaces for effective information management, for use by intelligent system prototypers and industry and aerospace developers of advanced operations software. The fourth objective is to identify and research solutions to the specific problem areas of supporting Mission and Safety Critical (MSC) software for extremely large, complex, distributed systems such as SSFP, and the Lunar/Mars missions which must evolve and operate ultra reliably, non-stop over many years. Current software engineering
Human Support Research and Technology

W93-70093 (21) 506-71
Ames Research Center, Moffett Field, CA.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
W. Berry 415-604-4930

The overall objective of this RTOP is to create a new technology base in advanced life support systems and extravehicular activity (EVA). The approach will be a coordinated research activity among industry, universities, and NASA in space suits, chemical processing, Portable Life Support Systems (PLSS's) and sensors. The objectives of the Space Suit Technology Element are to understand the requirements for advanced pressure suits and to demonstrate suit elements and assemblies. These objectives will be met using a combination of in-house and contracted design, fabrication, and testing. The results of this work will be applicable to pressure suits for both current and future flight programs. The objectives of the Chemical Processing Element are to develop new physical/chemical process technologies for air revitalization, water reclamation, and solid waste management that will provide the basis for advanced integrated, closed-loop life support systems. The approach is based on laboratory evaluation of new concepts, system trade studies, test stand and testbed evaluations, and state-of-the-art process modeling for use in space platforms, transit vehicles, and habitats. The objectives of PLSS's are to conceive, demonstrate, and characterize new concepts. These objectives will be met using a combination of in-house and contracted experiments, design, fabrication, and testing, beginning with applied research and ending with demonstrable prototypes. The results of this work will be applicable to portable life support systems for future flight programs. The objective of the Advanced Sensor Element is to develop technology for chemical environmental systems monitoring using ion trap mass spectrometry and expert systems. The approach will focus on enhancing the capabilities of a commercial ion trap mass spectrometer through the development of advanced hardware and artificial-intelligence-based control strategies. This technology will be applied to life support system monitoring, ecosystems monitoring, atmospheric chemistry research, and aircraft exhaust analysis. The objective of the University Research Element is to make universities an integral part of the NASA life support technology development process. The approach will be to provide support to university collaboration through formal solicitations, a NASA Research Announcement (NRA), and consideration of unsolicited proposals.

W93-70094 (10) 506-71
National Aeronautics and Space Administration, Washington, DC.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
Samuel L. Venn 
202-453-2760

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.

W93-70095 (55) 506-71
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
D. P. Maynard 818-354-8383

During FY-93, Life Support System Analysis (LISSA) software tool development for physical-chemical life support systems will be completed, including documentation, and sent to ARC and to others as directed by Office of Aeronautics and Space Technology (OAST). The development of a rigorous and comprehensive systems analysis tool for physical-chemical-biological life support systems will continue. JPL will continue to provide systems analysis tool development to JSC. The subcontract activity on objective technology assessment of extant life support technologies will continue through this FY.

Space Communications Research and Technology

W93-70096 (22) 506-72
Lewis Research Center, Cleveland, OH.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. W. Bagwell 216-433-3502

The overall objective of this RTOP is to provide through research, development, and experimental tests, the devices, components, and subsystems that comprise a suite of enabling technologies for new and improved space communications systems in support of NASA missions, the U.S. commercial communication satellite industry, and other government agencies. To achieve this objective, advanced research and development programs will be conducted in the following areas: electron beam devices and components; solid state devices and components; antenna systems incorporating active and passive phased arrays; digital components and subsystems; RF components and subsystems; and systems validation and testing. Work is performed in-house, on contract, and at universities for the purpose of developing advanced communication technology to enable systems that are frequency
spectra and power efficient, have longer life, and are low in weight and volume. Technology development is primarily focused on frequencies of 20 GHz to 94 GHz at information rates up to 1 Gbps. This work is expected to result in advanced components and systems for both commercial communications satellites and NASA data relay satellites, science satellites such as ‘Cassini’, and associated earth terminals.

W93-70097  (10) 506-72
National Aeronautics and Space Administration, Washington, DC.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
Samuel L. Vennan  202-452-2760
The objective of the Satellite Communications Application Research (SCAR) program is to develop and promote new processes, methods, or techniques that will enable new satellite communications capabilities or services. The SCAR program supports innovative applied research in satellite communications from both the public and private sectors whose implementation in the commercial marketplace will maintain U.S. preeminence. For future NASA planning, the program provides guidance to ensure continuing relevance of NASA's communications program to industry needs and to identify the 'cutting edge' enabling technologies. The work performed will provide U.S. industry with access to NASA-developed techniques or technologies for applications in improved satellite commercial services. The program will support key technology R&D to reduce industry risk and expedite commercial communications applications.

W93-70098  (51) 506-72
Goddard Space Flight Center, Greenbelt, MD.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
Michael A. Kranak  301-286-2646
This RTOP will develop and demonstrate high data rate optical communication technology for future NASA missions in the near Earth environment. The communications link is nominally a Geosynchronous Earth Orbit (GEO)-GEO cross link such as that required on the Future Services Growth portion of the Tracking and Data Relay Satellite System II (TDRSS II) and beyond. This RTOP is divided into two portions: (1) System Demonstrator; and (2) Advanced Components. The communication System Demonstrator will be capable of 650 Mbps return and 50 Mbps forward data rates. Emphasis is placed on small, low mass, low power dissipation terminals, which are capable of relaying high rate digital data with low bit error probability. The subsystems will be built to form fit and function requirements with space traceable component designs. The optical communication system will utilize a high power (greater than 1 W) 0.8 micron wavelength AIGaAs semiconductor laser system which will transmit digital data using a four slot pulse position modulation format. These devices will be hybrid integrated with a high speed, high current electronic driver circuit to achieve the required output power and data rate. This unit will be integrated into a small, space traceable optomechanical package which will provide a collimated, diffraction limited beam. Direct detection wide band receivers which use silicon avalanche photodiodes with hybrid integrated pre-amplifiers will detect the incoming intensity modulated signal. Bit synchronizers which have the necessary sensitivity, bandwidth, and low power dissipation will be developed at the LeRC and will be integrated into the system for end-to-end testing. The Advanced Component portion is developing a very high power (greater than 5 W) and data rate (greater than 2 Gbps) laser transmitter and receiver near the 1 micron wavelength. Because of the potential for very large transmitter power levels at this wavelength, this approach may ultimately offer important system level advantages (e.g., size, weight, pointing accuracy requirements, and cost). The NASA Vision 21 Strategic Plan, January 1992 states the following: 'The Communications and Data Systems effort must meet the quantum jump in data rate from spacecraft...' and 'the dramatic increase in requirements of the Hubble Space Telescope, Compton Observatory, UARS, Space Station Freedom, EOS, AXAF...'. Additional high data rate requirements will be incurred from the introduction of High Definition Television (HDTV) cameras on NASA spacecraft. The HDTV data rate is 1.3 Gbps. Optical intersatellite links (ISL’s) can potentially provide a high data rate transmission capability with small terminals, high reliability, and freedom from interference. Optical intersatellite link advantages are accrued from the laser's high operating frequency, efficiency, and smaller physical size. The principal advantages are as follows: greater bandwidths, smaller system divergence, smaller antennas, and reduced overall system weight and power dissipation. Communications systems operating at optical wavelengths have the additional advantages of low probability of interception and a high resistance to interference. This specific TDRSS II application will provide the near team focus for the systems technology being developed within this RTOP. The lasers and receivers developed under this RTOP can also be used in coded laser ranging and lidar remote sensing applications such as ARISTOTLES, GLAS on EOS, LASE, and Lunar Observer.)

W93-70099  (SS) 506-72
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
T. Jedrey  818-354-5187
The objective of this RTOP is to develop and demonstrate communications technology to meet future NASA needs and to transfer that technology to potential users, both in NASA and U.S. industry. The RTOP has four basic components. The first component is the Acts Mobile Terminal. The objectives of this portion are as follows: (1) to develop the advanced highly reliable space and terrestrial technologies and system concepts necessary for a commercially viable mobile satellite communications system at Ka-band; (2) to demonstrate speech/data transmission in the Ka-band land mobile satellite communications channel; (3) to provide a platform for the realization of the longer term goals of mobile, micro, and personal terminal development; and (4) to characterize the Ka-band land mobile satellite communications channel. To meet these objectives, Ka-band fixed and mobile communication terminals will be developed for experimentation with ACTS. This involves the development of multirate speech codecs, robust multirate modern modem of the communications channel, transceivers, and medium gain, steerable, low profile vehicular antennas. The second component is Optical Communications. The objective of this program is to develop optical communications transceiver technology for use on future NASA spacecraft. The short-term focus of the program is on the development of an Optical Communications Demonstrator (OCD) laboratory system which integrates all the key ingredients of a spacecraft transmitter terminal. These ingredients include transmit/receive telescope, coarse telescope pointing, transmit laser, and fine beam control pointing. The elements will be integrated into a full-sized terminal called the OCD instrument and will be supported by three ancillary systems: (1) the OCD Ground Simulator; (2) the OCD Controller/Power Supply; and (3) the OCD Test Support Equipment. The third component is the Mobile Satellite Communications Technology. The objectives of this program are to develop a Low Earth Orbit (LEO) mobile satellite terminal testbed and use it to carry out communications system performance evaluation through the proposed LEOEX payload on the first NASA COMET mission planned for launch in early 1993. This L-band mobile terminal will be designed and implemented by JPL using the existing terminal originally developed under the NASA Mobile Satellite-X (MSAT-X) Program. The LEOEX payload, which is currently under construction by Motorola in conjunction with the Space Communication Technology Center of the Florida Atlantic University, may have to be modified in order to accommodate other signal formats pertaining to other proposed LEO systems. It is anticipated that this testbed facility will be made available to all industry partners interested in the performance assessment of their respective systems. The fourth component is the High Temperature Superconductor Space Experiment 2 (HTSSE 2). The objectives of this program are as follows: (1) to complete the testing of the breadboard (BB) HTSSE 2 low noise X-band receiver and transmitter for delivery to the Naval Research Lab in 1993; (2) to iterate the BB design if necessary and hold a design review; (3) to fabricate all modules and housings for the three flight units; (4) to assemble and test all modules; (5) to integrate all JPL modules (filter and low noise amp) along with those delivered by NASA LeRC (mixer...
and oscillator) into the three flight housings; and (6) to deliver the final units to the Naval Research Lab for their evaluation for flight on the HTSSE spacecraft. It is assumed that Code R will fund NASA LeRC to complete all necessary hardware (mixers and oscillators) developed by LeRC for this project.

Hypersonic Research and Technology

W93-70100
Ames Research Center, Moffett Field, CA.

HYPERSONICS RESEARCH AND TECHNOLOGY
M. J. Green 415-604-5595

The overall objectives are to advance fundamental understanding of basic physical and chemical processes and to develop predictive capabilities for analysis and design optimization of advanced airbreathing hypersonic vehicles. A synergistic interplay between computational, ground-based experimental, and flight research will be used to validate the technology. These efforts provide the prerequisite research and technology developments enabling an improved and validated technology base for application by industry in the development of future generation hypersonic vehicles. The approach of this RTOP will be as follows: (1) to develop and validate new algorithms to reliably and efficiently simulate high altitude low density hypersonic nonequilibrium flows and to provide a generic hypersonic data base for accurate characterization and prediction of hypersonic aerodynamic and aerothermal environments; (2) to advance the development of generic research relating to materials and concepts for thermal protection systems and to understand and resolve hydrogen-materials incompatibility issues applicable to transatmospheric vehicles; and (3) to provide a hypersonic experimental database of sufficient accuracy to calibrate/validate the advanced CFD and engineering design codes used in the prediction of aerodynamic, propulsion, structural, thermal, and controls characteristics encountered on future hypersonic vehicles.

W93-70101
Langley Research Center, Hampton, VA.

HYPersonic RESEARCH AND TECHNOLOGY
L. M. Couch 804-864-3756

This research includes executing experimental and analytical programs to develop new, advanced technology in all areas of hypersonics: aerodynamics and aerothermodynamics; propulsion; materials and structures; guidance and control; and systems analysis and multi-disciplinary integration. In addition, supporting the advances in these areas is research aimed toward the development of advanced test techniques, test support methods, and measurement technology. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry. Results of this research will enable the development of efficient, viable hypersonic vehicles of all types, including reusable launch vehicles (both single and two stage) and cruise vehicles.

In-Space Technology Experiments

W93-70102
Ames Research Center, Moffett Field, CA.

IN-SPACE EXPERIMENTS
M. Kiss 415-604-5573

Artificial membranes are used in several technologies currently under advanced development for human life support in space. Such technologies will allow faster and less expensive separations of life support materials in hypogravity, for example, of water from gaseous radon and ions from water. The customer for these technologies will be advanced life support systems on space platforms, in transit vehicles, and in surface habitats. The objective of the Permeable Membrane Experiment is to evaluate the behavior of artificial membranes in microgravity, using the Space Shuttle as a research platform. The approach is to evaluate various kinds of membranes, including those with surfaces that range from hydrophobic to hydrophilic and pore sizes that result in membranes that are permeable, semi-permeable, or selectively permeable, for their ability to control gas, water, and ion flows in microgravity.

W93-70103
Lewis Research Center, Cleveland, OH.

IN-SPACE TECHNOLOGY EXPERIMENTS
O. D. Gonzalez-Sanabria 216-433-5252

The In-Space Technology Experiments Program supports the definition and development of flight experiments to evaluate and validate advanced technologies for future space systems. This RTOP addresses the technologies conceived and developed under industry independent research and development. The Lewis Research Center currently manages industry/university (I/U) flight projects in three technology themes: power systems, propulsion and propellant management, and human support. Included are four I/U flight projects: Tank Pressure Control/Thermal Phenomena (TPC/TP), Boeing Aerospace/LeRC; Vented Tank Resupply (VTRE), Martin Marietta; Sodium-Sulfur Cell Technology (SSCT), Space Systems/Loral; and Risk Based Fire Safety (RBFS), University of California at Los Angeles (UCLA). TPCE will obtain video and numerical data on the physics and thermodynamics of jet induced fluid mixing for pressure control of subcritical fluids and the thermodynamic mechanism of self pressurization in low gravity. Flight results are of direct relevance to space based fluids and thermal systems and directly applicable to pressure control technology for long term storage and transfer of cryogens in space, and supports transportation and exploration missions. VTRE will acquire video and numerical data on the effectiveness of a capillary vane device to retain fluid in a low gravity environment. The results will provide data for the design of future space based cryogenic and storable fluid systems required for SSF, orbital propellant depots, and spacecraft for planetary exploration programs. SSCT will examine the effect of microgravity operation in critical areas affecting cell performance and validate the design methodology for thermal control, charge/discharge control, safety and spacecraft integration. The results will validate the technology and support design of future spacecraft power systems. RBFS will develop an in-space combustion experiment to acquire data necessary for unique, quantitative risk assessment of spacecraft fire safety. The data will aid the development of improved, efficient, and cost effective fire protection techniques in the operations of SSF and other advanced spacecraft.

W93-70104
Langley Research Center, Hampton, VA.

IN-SPACE TECHNOLOGY EXPERIMENTS
J. F. Creedon 804-864-6033

This work is expected to complete the design and initiate the development of the Jitter Suppression Experiment and the Mid-Deck Active Controls Experiment (MACE); to conduct a reflight of the Mid-Deck Gravity Dynamics Experiment (MOGE); to complete the design and initiate development of the Joint Damping Experiment. Contracted efforts will be conducted on the work for MOGE, and to initiate the design and development of the Joint Damping, Jitter Suppression, and the MACE experiments.
This RTOP has two objectives. The first is to complete the Heat Pipe Performance (HPP) flight experiment, support the flight, complete the data analysis and generate a final report. The HPP is designed to provide data on the operation of heat pipes which are spinning in microgravity. Several types of pipes with various amounts of working fluids will be tested. The pipes will be spun at various rates to simulate g levels from near zero to one g. The experiment will be operated in the mid-deck of the shuttle. The crew will be involved in operating the experiment, gathering data and providing their insight in performing the experiment. The data obtained will be useful to industry in developing the next generation of communication satellites, many of which will be spinners. The data will also be potentially useful to the manned Mars mission and to the lunar base where gravity levels are much lower than here on earth. The second objective is to perform Phase B studies for two IN-STEP flight experiments. The first is the Liquid Motion Experiment (LME) which is intended to study the behavior of fluids sloshing in spherical and ellipsoidal shaped tanks. This will also be a mid-deck experiment which will take advantage of the capabilities of the crew. The LME will provide data on the effects of inertial waves in the fluids which cannot be easily studied on earth because gravity is so much stronger than the forces in inertial waves. The data from the LME will benefit designers of propulsion and thermal control systems for future flight programs. The second IN-STEP Phase B study will focus on the design of an experiment to validate an advanced active thermal control system which will make use of an enhanced condenser surface which can increase significantly the condensation heat transfer coefficients of the system. The experiment is called the Two Phase Flow (TPF) experiment. It will be flown as a Hitchhiker payload in the shuttle bay and use ammonia as the working fluid. The results of this experiment will benefit many future flight programs which need active thermal control systems.

This RTOP covers the following experiments: Emulsion Chamber Technology (ECT), Optical Properties Monitor (OPM), and Hydrogen Maser Clock (HMC). The goals of the ECT are to assess the radiation background encountered in emulsion detectors in orbits up to 400 km; develop or modify emulsion techniques as necessary to allow optimum use of the emulsion method in space, assess the effect of large amounts of shielding depths not yet measured in space flight; and provide dose vs. depth data to computational groups at NASA currently involved in radiation dose assessment in space. University of Alabama at Huntsville will design, build, and analyze the data from ECT. MSFC will supply environmental requirements, perform environmental tests and coordinate Space Transportation System (STS) integration. ECT will be the forerunner of dosimeters for use on the Space Station. The OPM will provide the requisite data for understanding the space environmental effects on materials and the mechanisms of these interactions. This knowledge will lead to development of improved materials and coatings while improving the accuracy of ground facilities and procedures for testing materials. OPM will be designed, built, and tested by a small business firm. MSFC will provide project management and technical oversight. The OPM can be used by the optics and thermophysics communities as a reliable testbed for in-space materials investigations. The objective of the HMC is to understand the in-space performance and systematic characteristics of a very high stability Hydrogen Maser Clock system intended for long-term continuous operation in space. This maser will be optimized for space flight and long-term stability and represents the state-of-the-art in frequency standards (or clocks). It incorporates the essential features of terrestrial hydrogen masers that have frequency stability of a few parts in $1 \times 10^{-16}$ for intervals of several hours. Smithsonian Astrophysical Observatory (SAO) will design, develop, build, and functionally test the HMC. MSFC will provide project management, technical oversight, environmental testing, and coordination with ESA (spacecraft) and GSFC (laser ground station). Development of a highly stable space clock is the linchpin for several general relativity programs as well as very long baseline interferometry. Other applications include extremely high precision tracking and navigation systems.

The objectives of the In-Space Experiments Program (IN-STEP) is to define and develop space technology experiments that support critical technology needs. Currently the program consists of experiments addressing improved understanding of glow emissions from spacecraft and an experiment to evaluate the performance of electrochemical cells in a low-G environment. The objectives of the Experimental Investigation of Spacecraft Glow (EISG) experiment is to study and characterize glow emissions in the ultraviolet, visible and infrared wavelength regions, and determine how these emissions vary with orbital altitude and spacecraft surface temperature. In the approach of the EISG, high-intensity glow emissions will be produced on a sample plate that will be viewed with a visible imaging spectrometer, an ultraviolet spectrometer and infrared detectors. Glows of different intensities will be produced by the natural atmosphere, thruster effluents and nitrogen released above the sample plate. After completion of the experiment and the data is reviewed by the scientific community, operational procedures and design guidelines can be baselined to reduce glow effects on future missions. The electrochemical experiment, has as its objectives, the investigation of the effects of a low-G environment on the possible improvement of electrolysis cells and to validate the water electrolysis concept for use in future space applications. The approach will be to conduct a shuttle mid-deck experiment with electrolysis cells at various current densities and temperatures over a five-day period. Effects of microgravity or the distribution of liquid electrolyte, the gas/liquid interfaces within the cell and the surface tension of fluids within the pores of the cell cathode, electrolyte matrix, and anode may result in lower cell voltage during operation. An O2/H2 recombining (fuel cell concept) may maintain a regenerable supply of water to the cell electrode during the experiment. In addition to the performance improvement the work is focused on the validation of the baseline oxygen generation life support concept for the Eight-Man Crew Capacity configuration of Space Station Freedom.

Interdisciplinary Technology
Civil Space Technology Initiative Program

Space Science Technology

W93-70109  (21) 582-03
Ames Research Center, Moffett Field, CA.

SCIENCE SENSING (REMOTE)
C. R. McCreight  415-604-6549
The primary objective of this activity is to develop and characterize advanced infrared (IR) detectors and detector arrays for future space astronomical applications. In this area, the work aims to demonstrate high-sensitivity, low-background performance from arsenic- and antimony-doped silicon impurity band conduction (IBC) detectors, advance the technology of extrinsic germanium IBC detectors, develop the GaAs photoconductor as an alternative to bolometers for 300 micrometer applications, and to continue to develop improved silicon low-noise, low-temperature field effect transistor (FET) readouts for detectors. New astrophysics objectives include demonstration of large-format IBC arrays (up to 256 x 256 elements), and development of array technologies for far-IR bolometers. New additional objectives for FY-93 are: (1) application of novel modern materials technology toward development of novel pyroelectric IR detectors optimized for operation at temperatures characteristic of passively-cooled systems, around 100 kelvin, and (2) development of a robust ionizing radiation detector for ambient temperature applications on planetary surfaces (elemental analysis) or remote platforms (radiation measurements). The approach is to carefully characterize Si:As and Si:Sb IBC arrays, in 10 x 50, 50 x 62, and 128 x 128 formats; to develop means of producing high-quantum efficiency Ge:B IR detectors by ion-implantation; to characterize next-generation ultra high-purity GaAs produced by epitaxial techniques; and to design and develop new alternate substrate 1.5 K FET's for extrinsic Ge detectors. Additionally, antenna-coupled microbolometer array architectures will be investigated, and exploratory large-format (30 micrometer pixel) IBC arrays will be tested. A stack of lithium-drifted silicon detectors will be developed, with appropriate background rejection techniques, for gamma-ray applications. The pyroelectric detector element will be pursued via a thorough survey of the literature, and development of prototype devices using selected low Curie temperature materials.

W93-70110  (23) 582-03
Langley Research Center, Hampton, VA.

SCIENCE SENSING (REMOTE)
F. Allano  804-866-6027
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, detector materials research, laser transmitter design and development, discrete and array detector design and development, lifetime and efficiency improvement through in-house, university grant, and industrial contract efforts. The remote sensors and detectors developed as a result of this effort will be utilized by atmospheric and space scientists for global measurements of atmospheric gases and aerosols (including ozone-related and greenhouse gases), for remote measurement of global atmospheric winds, and for gravitational, metrological, and interferometric measurements.

W93-70111  (51) 582-03
Goddard Space Flight Center, Greenbelt, MD.

SCIENCE SENSING (REMOTE)
Henry H. Plotkin  301-286-6185
Technologies are being developed for precision distance determination on space platforms, between platforms, and between space, lasers, and ground targets. These include advancing space-based laser transmitter and receiver capabilities, and incorporation in system test beds. Objectives are to support the Geoscience Laser Altimeter System (GLAS), the Lunar Scout, Global Topographic Mission (GTM), and Dynamics of the Solid Earth (DOSE) projects and stellar interferometer missions in orbit and on the lunar surface.

W93-70112  (55) 582-03
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SCIENCE SENSING (REMOTE)
V. Sarohia  818-354-6758
The Science Sensing (Remote) RTOP focuses on development of advanced submillimeter wave sensing and infrared technologies for future NASA missions. The objective of the Office of Aeronautics and Space Technology (OAST) Submillimeter Wave Sensor's Program is to develop space-qualifiable components required for submillimeter wave heterodyne receiver systems and to accurately characterize their performance. Performance goals include extending technical capability to higher frequencies (1200 GHz in the near-term, 3000 GHz in the far-term), improving sensitivity an order of magnitude, and developing a viable array technology. The research and development effort is targeted at components to enable technology demonstrations for the NASA submillimeter wave astrophysics missions (Submillimeter Intermediate-class Mission, Large Deployable Relelectrode and the Microwave Limb Sounder (EOS-MLS) for Earth remote sensing missions. To achieve the above goals, the submillimeter wave sensing program will develop key technologies in the following five subelements: (1) superconducting mixers - high-sensitivity, heterodyne mixers are required to carry-out astrophysics missions. SIS tunnel junction mixers will be developed, which have been identified as the best approach to achieve the required performance (the mixers operate at physical temperatures of 4 K); (2) solid state local oscillators - oscillators delivering 50 to 100 microwatts of power will be developed using multipliers or solid-state fundamental oscillators (planar varactor diodes will be developed for the multipliers); (3) receivers - the objective of this element will be to optimize the mixer mounts to provide performance closer to the needs of the SMIM instruments (in particular, the mounts will be optimized for 10 percent bandwidth, double sideband operation, and a broad bandwidth IF from 8 to 12 GHz); (4) focal plane mixer arrays - the objective of this task is to develop a focal plane array capability for submillimeter wave heterodyne receivers (focal plane arrays are required for LDR and greatly enhance the data-taking capability in a given period of time); and (5) receivers for earth remote sensing - the objective of this task is to develop receivers to provide the performance required for the EOS-MLS instrument. Subharmonic mixers with planar GaAs Schottky diodes and a very broad IF bandwidth (2-20 GHz) are being developed. These mixers operate at ambient temperatures. In addition to in-house research, a NASA Research Announcement (NRA) program will be put in place involving universities and industries active in the submillimeter sensing area. The JPL infrared detector program develops detector array technologies over a broad spectral range from MIRIR (4 microns) to FIR (beyond 200 microns) including broadband thermal detectors. The program consists of the following tasks: (1) GaAs/AIPGaAs quantum well and Si-based systems with response to 17 microns for operation above 65 K for the NASA Earth observing missions; (2) Germanium Blocked-Impurity-Band (GeBiB) Detectors to provide infrared coverage (30-250 microns) for astrophysics mission applications; and (3) thermal broadband detectors based on tunneling phenomenon (micro Golay-cell) and high temperature superconducting microbolometers, and low temperature (greater than 10 K) low noise multiplexer, readout and integration concepts for focal planes.

W93-70113  (62) 582-03
Marshall Space Flight Center, Huntsville, AL.

SCIENCE SENSING (REMOTE)
J. E. Clark  205-544-6726
The objectives of this RTOP are to develop and demonstrate the operation of a solid state Doppler lidar system which has
greater accuracy in measuring wind velocity, is more reliable and compact, and satisfies the requirements of the Laser Atmospheric Wind Sounder, an OSSA facility instrument for the Earth Observing System. The Laser Sensing Technologies Program is described in detail in the Integrated Technology Plan of March, 1992. This plan was prepared jointly by LaRC, MSFC, and GSFC. The plan describes three focus areas: Doppler Lidar, Differential Absorption Lidar, and Laser Metrology. MSFC has lead responsibility for the Doppler Lidar portion and for coordination and direction of the Centers' collaborative effort. LaRC is responsible for the development of the transmitter laser for this system under direct funding from OAST. A subcomponent, a frequency agile receiver will be developed by JPL under funding through MSFC. MSFC will integrate the components into a Doppler lidar system test bed and conduct characterization and verification tests on the complete instrument.

W93-70114
Ames Research Center, Moffett Field, CA.

OBSERVATORY SYSTEMS
P. Kittel 415-604-4297

The objectives are to develop and demonstrate advanced cryogenic coolers for future space applications. These coolers are required to have a high efficiency, low cost, an extended life, and good temperature stability. The technologies being developed were chosen to increase the usefulness of detectors and of overall sensor systems. Emphasis was placed on technologies that extend mission lifetimes (efficient, durable coolers) and those that extend the available range of operating temperatures (coolers for less than 10 K). These activities blend analysis with component development and include extensive in-house characterization, development, and technology demonstration. In carrying out the program, the work is coordinated with users and maximal use is made of existing facilities and expertise in industry, universities, and government agencies. This program element has three sub-elements. The first is the development of Pulse Tube coolers. These coolers have half the moving parts of Stirling-cycle coolers and no cold moving parts or seals. Thus, they are simpler and more durable than other coolers above 15 K. They are being developed for second generation Earth Observation System (EOS), Orbiting Very Long Baseline interferometer (OVLBI), and future Geostationary Earth Observation (GEO) applications. The second sub-element is the development of a high efficiency cooling stage to reach 2 K. The best candidate in this range is a magnetic Carnot cycle. This cooler is being developed for Large Deployable Reflector (LDR), Submillimeter Interferometer (SMMI), and Next Generation Orbiting Very Long Baseline Interferometer (NGOV/LBI) and its precursors. The cooler would replace the current technology of stored cryogens, extending mission times from less than 1 year to more than 5 years. The third sub-element is to extend the cooling capabilities to below 1 K for cooling long wavelength IR detectors on missions such as LDR and SMMI. The objective is to develop a 3He-4He dilution refrigerator to provide a modular, versatile cooler for temperatures down to 50 milli-Kelvin.

W93-70115
Goddard Space Flight Center, Greenbelt, MD.

OBSERVATORY SYSTEMS
S. Castles 301-286-5405

The objective of the Cooler Systems Program is to meet user requirements for cooling detectors and associated electronics, filters, and optics. Such cooling usually provides at least an order of magnitude improvement in performance. Needs will be met by three coolers. The long-life cooler is for the 20-55 K temperature range for long wavelength IR earth science and astronomy missions using HgCdTe detectors, quantum well detectors, and other advanced detectors. Potential users include the Earth Observing System (EOS) and the Advanced X-Ray Astrophysics Facility (AXAF). Payloads requiring liquid helium temperatures will use 20-55 K coolers as an upper stage. A dynamically balanced, two-stage linear Stirling cycle cooler will be developed. The 2-5 K mechanical refrigerator will have a lifetime exceeding five years, for IR, x-ray, gamma-ray, and cosmic ray missions such as the Large Deployable

Reflector (LDR), Submillimeter Interferometer (SMMI), and next generation AXAF and very long baseline interferometry (VLBI) instruments. Cycles with high thermodynamic efficiency will be used to meet the low input power requirements. The long-life vacuum-motion cooler is for the 50-80 K temperature range for use on missions with a fine pointing requirement, such as future Hubble Space Telescope (HST) instruments, space-based VLBI instruments, and interplanetary missions. Gamma-ray instruments such as the Nuclear Astrophysics Explorer (NAE) and GRISO with multiple sensors sensitive to microphonics are also potential users. High speed, miniature turbo-Brayton technology will be used to eliminate vibration.

Planetary Surface Technology

W93-70116
Lewis Research Center, Cleveland, OH.

SURFACE SYSTEMS
H. W. Brandhorst 216-433-6149

The NASA Civil Space Technology Initiative (CSTI) High Capacity Power Program is intended to augment the SP-100 Power System qualification (PSQ) being conducted by DOE/SDIO/NASA 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, growth at reduced weights, and longer lifetime with higher reliability. These goals will be attained by conducting the broad based research and technology program which includes 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.

W93-70117
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SURFACE SYSTEMS
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, optimization of silicon germanium thermoelectric materials will be completed and potential new high performance thermoelectric materials will be investigated. The approach focuses on optimizing dopant concentrations for n-type silicon-germanium materials to maximize Seebeck coefficient and on reducing thermal conductivity of n- and p-type silicon germanium by the addition of phonon scattering centers. Also, efforts to identify potential next generation thermoelectric materials for high capacity power generation will continue with the focus on Ge-rich, Sb-rich, and Bi-rich transition metal and rare earth compounds.

Transportation Technology

W93-70118
Lewis Research Center, Cleveland, OH.

(22) 584-03

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY
EARTH-TO-ORBIT TRANSPORTATION
L. A. Diehl 216-977-7506
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, as well as the development of low cost transportation systems for commercial vehicles. LOX/hydrogen 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. This program will provide a national preeminence in space operations, utilization, and exploration to ensure high performance, low cost, and reliability in future transportation systems. It will provide the technology base and engineering design methods to meet the challenging requirements placed on space propulsion systems by the advanced mission and space vehicles envisioned for the future.

W93-70119  (55) 584-03
Jet Propulsion Lab., California Inst. of Tech., Pasadena
EARTH-TO-ORBIT TRANSPORTATION
L. D. Strand 818-354-6904
The objective of this RTOP is to develop and demonstrate critical technology required to design high-performance, reliable, safe, and cost-effective hybrid rocket motors. The approach is designed to support and complement existing industry/government efforts and combines both experimental and theoretical activities. The former will consist of slab window motor studies using an existing test system that will be expanded and upgraded. The latter will consist of concluding the development of a state-of-the-art hybrid fuel combustion model. The first year slab burner study will be continued and extended, utilizing more sophisticated diagnostic instrumentation. This will include the following: (1) mass spectrometer measurement of the chemical species concentrations in the core flow; (2) laser Doppler velocimetry measurement of core flow velocity and turbulence level; and (3) incorporating infrared windows into the burner to allow radiometric measurement of the fuel surface temperature and thermal gradient profile in the core flow. A second objective is to provide support in defining the payoff potential of advanced technologies and assessing the impact of various technology efforts on meeting the goals of the Earth-To-Orbit (ETO) program.

W93-70121  (62) 584-03
Marshall Space Flight Center, Huntsville, AL.
EARTH-TO-ORBIT TRANSPORTATION
J. L. Moses 205-544-1747
The objective of this RTOP is to extend and further develop the earth-to-orbit propulsion technology base in support of current and future space transportation systems, including low cost commercial propulsion technology. The technology described herein encompasses 02/H2, 02/HC (Hydrocarbon), and hybrid propulsion and is directed at developing hybrid propulsion and enhancing liquid engine life, performance, and operability. The activity is divided into three categories: 02/H2 technology acquisition, 02/H2 technology validation, and hybrid propulsion technology acquisition. Technology acquisition activities for 02/H2 systems 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. Technology acquisition activities for hybrid systems include analytical model development and nozzle and feed system performance evaluations. The 02/H2 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 tested in Technology Readiness Level 6 is the validation goal. The low cost activity in FY-93 will include the following: (1) hybrid propulsion - to define nozzle erosion and low cost turbopump operation in a 40K thrust motor; and (2) subscale 40K thrust liquid bipropellant combustor test and evaluation to define the characteristics of a system employing a pindle injector with an ablative combustion chamber. Cooperative agreements with industry will provide for Government personnel test support for industry furnished test hardware.

W93-70122  (22) 584-04
Lewis Research Center, Cleveland, OH.
SPACE TRANSPORTATION
S. J. Grisaffe 216-433-3193
The objective of the Advanced Cryogenic Engines program is to provide the technology necessary to proceed with the development of moderate-thrust (7,500 to 200,000 lb) liquid oxygen/liquid hydrogen rocket engines for various space transportation applications. These applications include upper stages, near-earth orbit transfer, and Lunar and Mars transfer and excursion vehicles. Expected near-, moderate-, and far-term needs are addressed for both expendable and reusable configurations. The approach includes the following: (1) identification and assessment of technology requirements; (2) identification, creation, and/or validation of design and analysis methodologies; (3) development of materials with required properties, and reliable, cost-effective manufacturing processes; and (4) development and validation of engine and support hardware subcomponent, component, subsystem, and system technologies focused on improved reliability, operational efficiency, wide-range operation, low-cost manufacturing, and improved performance. The overall effort is organized as follows: (1) centered around the Advanced Expander Test Bed (AETB) in which the developed technologies and hardware designs will be validated in a systems environment; and (2) coordinated and integrated with other NASA and Air Force space propulsion programs. The objective of the Nuclear Propulsion Project is to develop and demonstrate technology readiness for safe and reliable nuclear propulsion systems to support piloted and robotic exploration of the solar system. Space Exploration Initiative requirements will drive the definition of candidate nuclear propulsion concepts and these concepts will direct the enabling technology. In FY-93 the Nuclear Thermal Propulsion (NTP) will focus on conceptual design and systems engineering, safety and environmental studies, a prospective public information program, and facility definition. This effort is planned to be funded jointly by the Department of Energy (DOE) and NASA. The technology development will be conducted by a team consisting of NASA Centers, national laboratories, industry, and academia. Each
organization will contribute in the areas of their respective expertise.

W93-70123  (62) 584-04
Marshall Space Flight Center, Huntsville, AL.

SPACE TRANSPORTATION
M. S. Swint  205-544-4060

The objective of the Advanced Cryogenic Engines program element is to provide the technology necessary to proceed in the late 1990's with the development of moderate thrust liquid oxygen/hydrogen (LOX/LH2) expander cycle engines. Studies have shown that propulsion systems needed for the next generation of transfer, excursion, and upper stage vehicles must be highly reliable and achieve high performance within a limited engine envelope. The approach includes efforts focusing on developing and validating engine subcomponent, component, subsystem, and system technologies to address improved performance, high reliability, operational efficiency, reduced cost, and engine health management. The essential technology tool of the program is the Advanced Expander Test Bed (AETB). The testbed will reproduce the key operating conditions of an advanced cryogenic engine in a flexible and realistic way. It will provide a mechanism for validating the high pressure expander cycle concept and its advanced component technologies. It will also provide a means for developing and validating system interaction, transient, dynamic, and steady-state models and health monitoring techniques. The advanced engines that will be developed based on this technology program, will satisfy multiple users needs including: the commercial launch industry's need for high energy upper stages providing increased payload capability; the National Launch System's (NLS) need for a high energy upper stage providing high performance orbit insertion and transfer capability, and the science/exploration community's need for high performance transfer stages and descent/ascent vehicle capability.

Space Platforms Technology

W93-70124  (22) 585-03
Lewis Research Center, Cleveland, OH.

EARTH-ORBITING PLATFORMS
H. W. Brandhorst  216-433-6149

The objective of this program is to conduct a ground test and evaluation of the design and performance of a complete 2 kWe Solar Dynamic Space Power System. Testing will be conducted at NASA Lewis under simulated conditions of space vacuum and solar input. Major test components of the Solar Dynamic (SD) Ground Test Demonstration (GTD) System include a solar concentrator, a heat receiver with thermal storage, a turbine-alternator-compressor (TAC) assembly, a recuperator, a gas cooler, heat rejection and parasitic load radiators and a load simulator. The TAC and recuperator were previously developed and tested under separate NASA/DOE contracts. Testing and evaluation will be conducted at the component, subsystem and system level. For maximum experimental value, the thermodynamic, optical and heat transfer design will be consistent to the largest extent practical with actual space flight operation. The designs of new components will be scaled from solar dynamic design concepts developed under the Space Station Freedom Program. Testing will include operational conditions of heat-up, start-up, steady-state operation, transient operation, and planned and unplanned shutdown. Sun-shade cycles will be simulated and design and performance will be evaluated under normal and abnormal operation conditions.

Operations Technology

W93-70127  (21) 586-02
Ames Research Center, Moffett Field, CA.

AUTOMATION AND ROBOTICS
H. Lum  415-604-6544

The objective of the artificial intelligence (AI) program is to develop, integrate, and demonstrate the science and technology of Al 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:

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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 applied research in planning, scheduling, and design of and reasoning about large-scale physical systems. It also encompasses specific applications projects which have grown as spinoffs from the research work. All of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly Defense's Advanced Research Projects Agency (DARPA's) Computational Sciences Technology Office (CSTO). Research in scheduling techniques will result in cost savings and more effective use of scarce resources for a variety of Agency missions. Shuttle Orbiter ground processing and Hubble Space Telescope science scheduling are two particular domains that have already benefited from the work. Research in planning methods is focused on increasing the science return from missions (such as EOS) that require the coordination of knowledge from multiple agents and disciplines. Research in physical systems has centered on better techniques for modeling, diagnosing, and controlling space vehicles, both from the ground and in-flight with a current emphasis on Shuttle Orbiter fault management. The current year effort will be focused on computer-integrated documentation, intelligent assistance for crew-conducted science space, and intelligent scientific instruments, benefit the Space Station Freedom engineering, in-flight life science, and geochemistry communities respectively.

W93-70128 (22) 586-02
AUTOMATION AND ROBOTICS
H. W. Brandhorst 216-433-6149

The program objective is to provide technology development/transfer for application of knowledge-based systems to the space power electrical systems domain. This is a continuing effort at LeRC to demonstrate cooperative fault management and power scheduling software using appropriate power testbed facilities. The effort to date has resulted in development and demonstration of a prototype fault diagnostic expert system and associated load power scheduler with a small scale electrical power busbar. The previous year's work included introduction of model-based reasoning approaches in the fault diagnostics and use of a temporal-phased scheduling process to incorporate both reactive and predictive methodologies within a single scheduling prototype. The current year effort will emphasize the following four technology enhancement areas: (1) extension of an existing model-based fault diagnostic expert system to incorporate LeRC Space Station Freedom (SSF) Electrical Power System (EPS) computer network facility; (2) extension of the scheduler to incorporate energy storage management capabilities and better handle resource/activity uncertainties; (3) evaluation of fuzzy methods for SSF battery management; and (4) investigation of methods to support cooperative fault, scheduling and battery systems on SSF network.

W93-70129 (23) 586-02
AUTOMATION AND ROBOTICS
J. F. Creedon 804-684-6033

The objective of the activity is to enable efficient, robust, and safe accomplishment of space tasks using telerobotic systems. Available technology and advanced technology developed under the basic research program are integrated to enhance current capabilities and increase operational efficiency. Work concentrates on realistic ground and space tasks in areas of high potential payoffs for telerobots. First, application of automation and robotics will be approached to increase the scientific productivity of microgravity experiments. Working with Principal Investigators, full scale experiment mockups will be tested in a simulated laboratory facility to investigate methods to increase the quantity and quality of scientific data. Second, the leading Flight Telerobotic Servicer (FTS) Technology Capture effort to maximize the retention of U.S. space telerobotic technology originating from the FTS program will be investigated. In a joint program with JSC, a software development system and ground testbed at LaRC will be used to develop and test technology for an FTS flight arm at JSC. Third, participation in cooperative efforts with KSC to apply advanced telerobotics sensing and controls technologies to improve the efficiency of shuttle launch processing operations will be performed. This includes methods for automatic inspection, anomaly detection and maintenance under remote supervision. Finally, automated planning and robotic assembly of large planar truss structure and attached fixtures, with application to remote assembly of nonplanar structures and large antennas will be evaluated. Advanced technologies in planning, scheduling, sensor-based control, and expert system monitoring and error recovery will be integrated and tested in cooperation with structural designers in the LaRC Automated Structures Assembly Laboratory. Intraventricular automation and robotics applications will increase the productivity of scientific experiments during the man-tended period of Space Station Freedom (SSF) operations. The FTS technology program, conducted cooperatively with JSC, is the foundation for future U.S. space telerobotic systems, and will result in development of flight manipulator hardware for JSC. An automatic inspection system for being developed for Space Station Freedom. The Integrating High-Level State Management and Fault Detection Expert System will perform postflight inspection and anomaly detection of shuttle thermal tiles, alleviating a manually-intensive operation and reducing operating costs. Remote assembly of large structures would reduce extravehicular activity (EVA) assembly operations and make large structures feasible in regions beyond shuttle capability including the Moon and Mars.

W93-70130 (55) 586-02
AUTOMATION AND ROBOTICS
Carl F. Ruoff 818-354-6499

This RTOP consists of two main elements: telerobotics and artificial intelligence. In telerobotics the general objective is to develop, demonstrate, and transfer to users a suite of telerobot system technologies. The program is designed to enable a new generation of missions and is focused on four main space system paradigm: Robotics, Supervisory Control, Teleoperation, and Terrestrial Robotics. In Robotics, the Human-Controlled Microvessel task develops Early System Concepts for an Advanced Robotics System that interface with limited capabilities required to operate the Go-For microvessel with limited communications bandwidth, onboard computational power, and communication latency. The Integrating High-Level State Information in Behavior Control task develops and tests behavior-controlled robots that use high-level state information to achieve goal-directedness. The Behavior Control for Cooperative Agents task develops behavior control techniques for combining multiple independent processes in performing cooperative robotic tasks. The Safety System for Robots Near Flight Hardware task develops a robotic system that utilizes multiple non-contact sensors and other safety mechanisms to provide robust collision prevention. In Supervisory Control, the Remote Surface Inspection task develops and evaluates telerobotics technologies required to perform surface inspection and non-destructive evaluation tasks in space. The Lab Tending Telerobot task develops a prototype ground-remote telerobot system for tending space-based laboratory experiments. In Teleoperation, the Advanced Teleoperation task addresses performing relatively unstructured remote manipulation tasks in space by use of advanced sensing and computer-aided teleoperation devices and techniques. The Telepresence (Exoskeleton) task will develop and evaluate telemanipulation capabilities enabling human-equivalent dexterity for space tasks involving remotely-operated hands. In Terrestrial Robotics, the Ground Emergency Response Vehicle task will develop and apply robotics technologies to reduce the health risk to humans involved in dealing with hazardous materials. The Satellite Test Assistant Robot task will apply telerobotic technology to space and...
spacecraft environmental testing and assess the cost savings that result. The artificial intelligence (AI) objectives are: to apply and extend mature AI technologies in the areas of monitoring, diagnosis, simulation, design, planning, scheduling, data analysis, software reuse and testing; to develop and demonstrate low-cost technology for addressing current mission operations and scientific data analysis needs; to meet long-term JPL and NASA needs by performing research in model-based reasoning, planning and scheduling, and machine learning. The overall objective of the Ground Data Systems Automation task is to develop and demonstrate AI-based automation technologies that provide multi-mission capabilities for spacecraft ground systems and the Deep Space Network (DSN). The main objective of the Operations Mission Planner (OMP) task is to extend the OMP prototype into an operational domain, the Deep Space Network 26 Meter subnet (DSN 26M). A primary objective of the System Test Maker (STEM) task, which addresses space system testing and certification, is to provide knowledge-based assistance in building test cases through the reuse of historical test cases from previous projects. The overall goal of the Design Evaluation Environment task is to construct a prototype design evaluation environment for reasoning about fault dependencies in system design by integrating capabilities from two existing tasks: FEAT at JSC and SELMON at JPL. The overall goal of the Scientific Analysis Assistant (SAA) task is to develop intelligent tools and techniques for use by scientists in preparing, archiving, manipulating, analyzing, and visualizing science data from unmanned planetary spacecraft and other sources. In both telerobotics and Artificial Intelligence, system capabilities will be developed to address the needs of specific users. Close interactions with users will exist throughout all phases of technology development.

W93-70131
Marshall Space Flight Center, Huntsville, AL.

AUTOMATION AND ROBOTICS
J. E. Clark 205-544-6729

(1) The Space Station Module/Power Management and Distribution (SSM/PMAD) task consists of several autonomous agents that must cooperate to control a power distribution subsystem in the SSM/PMAD breadboard. This task refines modes of operation and provides operating software where expert systems, embedded systems software, and humans must interact for scheduling, planning, fault diagnosis and isolation, load prioritization, and interface control. (2) The Advanced X-Ray Astrophysics Facility (AXAF) Automated Power System task objective is a proof of concept demonstration of an automated AXAF test bed Electrical Power System (EPS). The approach is to transfer the knowledge and experience gained from previous award of EPS projects to the AXAF program and use it to influence the design concepts to be incorporated into the flight and ground systems. The automated EPS concepts will be tested and demonstrated on an actual AXAF hardware testbed. (3) The Optical Plume Anomaly Detection Expert Diagnostic Filter System (OPAD-EDIFIS) task will modify and apply automated data analysis and diagnostic tools under development at Ames Research Center (ARC) to enhance the capability of OPAD data reduction at Marshall Space Flight Center (MSFC). The result would be an autonomous plume analysis data system for liquid rocket engines that can operate without direct human analytical input. Run time for the program is expected to be shortened considerably but the program output is still post test.

W93-70132
Lyndon B. Johnson Space Center, Houston, TX.

AUTOMATION AND ROBOTICS
N. H. Chaffee 713-483-9995

This research and technology proposal has two primary technical areas: (1) telerobotics; and (2) artificial intelligence. The telerobotics project includes surface inspection technology transfer, Special Purpose Dexterous Manipulator (SPDM) emulation, and the Flight Telerobotic System (FTS) technology capture program. The surface inspection project transfers surface inspection technology to be integrated and evaluated in the Automated Robotic Maintenance of Space Station (ARMSS) testbed under development at Johnson Space Center (JSC). At JSC, the technology will be evaluated in high fidelity Space Station Freedom (SSF) environments that include orbital lighting and realistic damage on SSF Orbital Replacement Units. In addition, computer software associated with this technology will be hosted on computers that model the SSF hardware and software environments. The JSC effort is focused on developing this technology to operational readiness. The SPDM emulation project provides for the control of the ARMSS robots in a fashion similar to the Canadian SPDM. This emulation is critical to the evaluation of candidate technologies transferred to JSC from the Canadian research centers. The FTS technology capture program seeks to capture R&D investment in the flight manipulator. Efforts are planned to characterize and partially certify the arm through a series of tests to be performed at JSC. The FTS arm has been proposed for use in an Orbiter teleoperator flight experiment. The final task involves grasping of freely moving objects, including the development of a system capable of visual recognition, tracking, rendezvous and acquisition of moving objects and touch guided final prehension and grasp stabilization via adaptive control of dynamic interactions. In the artificial intelligence area the objectives are to develop and transfer artificial intelligence technology into manned space operations to improve the quality of monitoring and control of space vehicles (Shuttle and Station), to assist in flight software regression testing, and to reduce the level of manpower required for such activities. Artificial intelligence applications are being developed and fielded in the Shuttle’s Mission Control Center (MCC). Expert systems are being developed to recognize and diagnose software problems uncovered during verification testing of Shuttle flight software loads. These applications are being developed by the customers themselves, the Mission Operations Directorate. A Design Evaluation Environment (DEE) which provides methods for automatically generating digraph models from system simulation data is being developed jointly by JSC and the Jet Propulsion Laboratory (JPL). The DEE could significantly reduce the time and manpower required to generate digraph models (which are baseline for monitoring and diagnosis in the Space Station Control Center).

W93-70133
John F. Kennedy Space Center, Cocoa Beach, FL.

AUTOMATION AND ROBOTICS
Tom C. Davis, Jr. 407-867-2760

The objective of this RTOP is to identify, apply, and demonstrate the use of artificial intelligence and robotic technologies to solve specific problems in NASA launch vehicle and payload processing operations at Kennedy Space Center (KSC). The primary project approach is to introduce, within three to five years, automation and robotic applications into those areas that will improve operations efficiency as well as increase safety, quality, and reliability. Production qualified prototypes and software are being developed to demonstrate feasibility to the user community. Operational field tests are being performed to validate the use of these technologies and to effect complete technology transfer into the user community. It is anticipated that complete verification and acceptance of automation and robotics technologies in complex ground operations will lead to acceptance of these technologies for space-based operations. This task includes three robotic activities and three activities in artificial intelligence (AI). The Tile Processing Robotic System will inject the orbiter bottomside tiles with rewaterproofing solution (an organic solution that gets burned out every reentry) and inspect the surface of these tiles for damage. It will automate much of the paperwork involved with both operations. The customer for this robot is the Orbiter Mechanical System Division at KSC. The High Efficiency Particulate Air (HEPA) Filter Inspection Robot will inspect the HEPA filters in the ceilings of the payload changeout rooms at Pads A & B for cracks and dislodgements due to launch acoustic vibration damage. The customer for this robot is the Payload Operations Division at KSC. The automated radiator inspection service will inspect the surface of the STS payload bay radiator for damage and delamination while the orbiter is in the Orbiter Processing Facility. The artificial intelligence (AI) portion of this task includes
the production of a distributed architecture shell which will allow the integration of independently-developed intelligent applications into a unified intelligent operations support tool. This tool, an Expert System for Operations Distributed Users (EXODUS), will share resources such as real-time data and access to knowledge bases. Other AI areas of activity relate to the knowledge-based systems which will be included as components to be integrated by this distributed environment. One AI area is the General Planning and Scheduling System (GPSS), which supports the massive scheduling of configurations and resources for processing the Orbiter in the Orbiter Processing Facility. The other is the Knowledge Based Autonomous Test Engineer (KATE) advisory system shell, which models, monitors, and diagnoses various vehicle subsystems. The resulting integrated demonstration environment will facilitate the deployment of intelligent systems for KSC operations support. The primary customer for these activities is the Shuttle Management and Operations Directorate. However, it is expected that the software tools developed by these projects will be transportable to other application areas within KSC.

W93-70134
Ames Research Center, Moffett Field, CA
INFORMATION AND COMMUNICATIONS
H. Lum 415-604-6544
The objective of the artificial intelligence (AI) 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 applied research in planning, scheduling, and design of and reasoning about large-scale physical systems. It also encompasses specific applications projects which have grown as spinoffs from the research work. All of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly DARPA’s Computational Sciences Technology Office (CSTO).

W93-70135
Langley Research Center, Hampton, VA
INFORMATION AND COMMUNICATIONS
F. Allario 804-864-6027
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 very high speed integrated circuit (VHSIC) multiprocessor technology, erasable optical media, laser diode arrays, multichannel controller, optical disk drive, fiber optic integrated circuit transceivers, and an advanced flight computer.

W93-70136
Goddard Space Flight Center, Greenbelt, MD
SPACE DATA SYSTEMS
D. Dalton 301-286-5659
The objectives of this RTOP are to develop and demonstrate algorithms and applications that can exploit, in Earth orbit, data compression or data analysis that can be programmed and controlled onboard by scientists from their laboratory and received at their workstation. Data compression algorithms will be identified, implemented, and tested on classes of data such as those from the Advanced Very High Resolution Radiometer (AVHRR), the Airborne Visible Infrared Imaging Spectrometer (AVIRIS), the Coastal Zone Color Scanner (CZCS), Scanning Multichannel Microwave Radiometer (SMMR), and Solar Optical Universal Polarimeter (SOUP). Customers include EOS Project and Moderate Resolution Imaging Spectrometer (MODIS) instruments. One task was to fabricate and test a GaAs SPARC RISC processor chip using the chip design from an SBIR. Customers include EOS and FUSE for instrument processing. A lossless data compression task was to design, fabricate and test a chip that implements a lossless data compression algorithm. The chip will be designed by the University of Idaho. This chip has been baselined by the Submillimeter Wave Astronomy Satellite/Small Explorer and the Gas Chromatograph Spectrometer/Cassini projects. Other customers include EOS. A pipeline processor task was to design, fabricate and test the Ultra-High Speed Data Acquisition system as a cooperative task with the Office of Naval Research. Customers include EOS and other instrument developers. A VLSI design of the pipeline processor data path element will be initiated at the University of Idaho. The lossy compressor task was to develop a quick-look capability for scientific data using source encoding to reduce channel bandwidth by a factor of 4 with selectable factors up to 20, and to develop lossy algorithms using transform coding techniques coupled with lossless source encoding algorithms that will provide optimal performance in the space environment and will be adaptive over the space-to-ground link using VLSI technology. A medium rate network task was to evaluate medium rate network protocols that support data rates between Mil Std 1773 and Fiber Distributed Data Interface (FDDI) capabilities and select one for development in a space qualifiable configuration. A promising implementation would include VLSI techniques using the University of Idaho to fabricate a chip set on a radiation hard process. This task replaces the Configurable High Rate Processing System (CHPRS) Enhanced Testbed which was deleted due to the downsizing of the EOS Project. A CHPRS initial testbed task was to maintain the initial testbed for demonstrating technology developments in a system environment and to provide a mechanism for technology transfer to users.

W93-70137
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION AND COMMUNICATIONS
John M. Davidson 818-354-7508
The objective of this RTOP is to conduct research and develop technology which will provide NASA with the space data systems and system components needed for future missions. This RTOP is part of the OAST Space Technology Program and will be managed in accordance with its program plan. Data system technology development included in this activity will enhance the ability to make productive scientific use of collected data and enable the deployment of autonomous systems to carry out new and unique missions. The technical objectives of this element are as follows: (1) Advanced Flight Computers: To significantly advance NASA’s computing capabilities by developing new general-purpose computer architectures for spaceborne applications. This task will seek architectural solutions that will lead to reduced volume, mass, power, and cost, increased performance, fault-tolerance, long-term reliability, and readiness for flight qualification. These solutions will be based on user needs and availability of state-of-the-art commercial technology; (2) Nonvolatile Random Access Memory: To develop nonvolatile random-access computer memory technology for spaceborne applications which provides high storage density, high data rates, short access times, radiation hardness, and long-term reliability, while also reducing mass, volume, and power consumption; (3) Vertical Block Line Storage Chips: To develop block access (disk replacement) mass storage technology to increase on-board data.
handling flexibility. The resulting devices will provide for high storage density, high data rates, nonvolatility, radiation hardness, while also reducing mass, volume, and power consumption. It is especially crucial that the new memory devices require no mechanical (i.e., moving) parts which could compromise the long-term reliability of the system; (4) Digital Autocorrelator Spectrometers: To develop and demonstrate space-qualifiable low-power digital autocorrelator spectrometers using VLSI technology. In FY-93, a B4 channel, 500 MHz bandwidth digital spectrometer will be developed. It will use specially designed CMOS chips which operate at 1 GHz clock rate and reduce DC power consumption; (5) Advanced Image Processors: To develop and demonstrate space-qualifiable special-purpose processors, including the development and demonstration of efficient algorithms for real-time processing of high-rate imaging instrument data streams and the design, evaluation, and demonstration of flight-compatible architectures for implementation of these algorithms; (6) Common Space Multicomputer Operating System: To develop an adaptable, general purpose, fault tolerant, multi-computer operating system which has a software development environment tailored for flight projects; and (7) Technology Assessments: To support the NASA OAST Data Systems Technology Working Group (DSTWG) in maintaining and upgrading the Civil Space Technology Initiative (CSTI) Data Systems Technology Program Plan.

Planetary Geology/Geophysics

W93-70138 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, 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.

W93-70139 151-01-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETOLOGY
C. F. Yoder 818-354-2444

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 and processes. 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 that 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 the Jet Propulsion Laboratory (JPL), including the NASA Regional Planetary Image Facility.

W93-70140 151-02-00
Goddard Space Flight Center, Greenbelt, MD.
EARLY MARS: IMPACT BASINS, CRUSTAL DICHTOMY, VOLCANIC RESURFACING
Herbert Frey 301-286-5450

The objective was 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, and to the relative importance of endogenic and exogenic processes in such evolution. The approach was to extend the search for evidence of large impact basins, with emphasis on the central southern highlands and especially the south polar region where our current inventory shows an exceptionally low number of large impact basins; to map in detail the multiple ring structure of South Polar Basin and its relation to ridged plains volcanism in this area; to 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; to 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 to determine if additional outcrops of Npl r ridged plains are truly Noachian in age, or Hesperian-age flows so thin that Noachian age craters show through.

Planetary Materials/Geochemistry

W93-70141 152-11-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: MINERALOGY AND PETROLOGY
Gordon A. McKay 713-483-5041

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.

W93-70142 152-12-40
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY
Gordon A. McKay 713-483-5041

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.

W93-70143 152-12-40
Goddard Space Flight Center, Greenbelt, MD.

A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRE SOLAR GRAINS
J. Nuth 301-286-9467
(188-44-57)

The objectives of this program are to: (1) determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur as the result of thermal annealing, hydration, and exposure to cosmic rays. The result will be the characterization of the grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored by 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 induced changes studied by the above techniques. Accomplishment of objectives 2 and 3 also require 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.

W93-70144 152-13-40
Lyndon B. Johnson Space Center, Houston, TX.

PLANETARY MATERIALS: CHEMISTRY
Gordon A. McKay 713-483-5041

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 will be supplemented, 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.

W93-70145 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 organic matter and volatiles 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 light elements are measured, and the occurrence and distribution of various organic components are determined in meteorites. Systematic searches for elemental, isotopic, and molecular 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. 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.

W93-70146 152-14-40
Lyndon B. Johnson Space Center, Houston, TX.

PLANETARY MATERIALS: GEOCHRONOLOGY
Gordon A. McKay 713-483-5041

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.

W93-70147 152-17-40
Lyndon B. Johnson Space Center, Houston, TX.

PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES
Gordon A. McKay 713-483-5041

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 performed using selected samples.

W93-70148 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 due to thermal convection. This problem is especially severe for refractory species such as SiO, Al2O3, and SiC which are important in both astrophysics and meteoritics. Well controlled studies of particle coagulation are difficult to perform on earth since larger particles tend to settle out just as the experiments produce aggregates of macroscopic
size. We will construct and test a system which will yield high quality data on the nucleation of refractory materials and also produce a cloud of well-characterized particles which would be used to carry out studies of particle coagulation on a number of refractory species aboard NASA's KC-135 research aircraft. We will also characterize the magnetic properties of the Fe-Ni system and the magnetic record contained in meteoritic materials. 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 25 s) 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.

W93-70149 152-20-40
Lyndon B. Johnson Space Center, Houston, TX
PLANETARY MATERIALS: COLLECTION, PRESERVATION AND DISTRIBUTION
James L. Gooding 713-483-5126
The objective was to provide for maintenance of the Lunar Sample Collection under secure, controlled environmental 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 preparing lunar samples to approved investigators and for display purposes; for technical monitoring of NASA-funded grants/contracts to Planetary Materials Investigators; for similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; for dissemination of information on meteorite collection; for staff members' participation in field collection; for the collection of cosmic dust samples using high altitude aircraft; for the characterization of dust particles; for distribution to scientific investigators; for dissemination of information; and for development of curatorial techniques for, and educational use of, materials from the various collections. The operation, which is undertaken by support contractor personnel, is directed by Civil Servant scientists and administrators. The program provides documentation and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and ten cosmic dust investigator groups.

W93-70150 152-30-40
Lyndon B. Johnson Space Center, Houston, TX
PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES
Gordon A. McKay 713-483-5041
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, and visits 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. This RTOP also includes JSC expenses for the Lunar and Planetary Science Conference and support for the Lunar and Planetary Institute per JSC-LPI Memorandum of Understanding.

W93-70151 152-88-10
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STUDY OF POTENTIAL MARS OBSERVER - MARS 94, 96
J. K. Campbell 818-354-5768
The long-range objectives were to provide coordination between U.S. and Russian scientists, and the Deep Space Network (DSN) with regard to radio metric tracking, and to negotiate tracking passes for navigation and science returns, based on technical benefits analyses. The short-range objectives were to perform error covariance analyses to establish benefits to relevant U.S. and Russian science objectives of various DSN tracking modes and data types; Doppler, ranging, VLBI, as well as optical imaging as appropriate; to coordinate these analyses with Russian navigators to obtain agreed-upon results, to understand the capabilities of Russian tracking facility, and assumptions made in analyses; and to analyze Voyager tracking signal acquired by Russian antennas, for assessment of quality. The long-range approach was to represent the Mars 94 mission to the DSN Resource Allocation Board, and negotiate for tracking passes identified by analyses as being beneficial to U.S. and Russian science objectives. The short-range approach was to attend the U.S.-Russian JWG meeting in September 1992; organize kickoff meeting in Moscow October 1992; and agree on scope, content, and assumptions relevant to producing navigation and gravity model error analyses for each phase of the Mars 94 missions.

Planetary Atmospheres R&A

W93-70152 154-10-80
Ames Research Center, Moffett Field, CA
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-604-5530
(196-80-00)
The objective of this RTOP is to determine the properties and physical processes characteristic of planetary atmospheres by means of theoretical modeling and spacecraft and ground-based 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.

W93-70153 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 various phenomena, such as 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.

W93-70154 154-20-80
Goddard Space Flight Center, Greenbelt, MD
DYNAMICAL PROPERTIES OF PLANETARY ATMOSPHERES
F. M. Flasar 301-266-3071
This RTOP supports advanced data analysis of dynamical properties of the outer planets' atmospheres. Task-01 addresses a comparative study of the zonal mean circulations of the giant planets.

W93-70155
Ames Research Center, Moffett Field, CA.

PLANETARY CLOUDS PARTICULATES AND ICES
O. B. Toon 415-604-5971

The goals of this program are: (1) to determine the nature and properties of clouds and aerosols on Mars and Titan; (2) to determine the physical and chemical processes responsible for the cloud structures observed on Mars and Titan; (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 was 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, as well as dust storms and water ice clouds on Mars.

W93-70156
Goddard Space Flight Center, Greenbelt, MD.

SPECTRAL AND PHYSICAL PROPERTIES OF PLANETARY ATMOSPHERIC CONSTITUENTS
D. C. Reuter 301-286-2042
(196-41-54; 198-44-57; 486-21-02)

The principle goals of this laboratory program are to measure the spectral line parameters, energy transfer processes and thermodynamic properties of planetary and cometary constituents under appropriate conditions, e.g., temperature and pressure. Accurate laboratory data are critical to proper modeling and interpretation of observations. For example, in the case of lower resolution planetary observations, such as Voyager IRIS (4 cm-1), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features appear in medium or high resolution Fourier transform spectra (FTS) are composed of more than one molecular transition, and the parameter's frequency, strength, lower state energy, and foreign-broadening must be known for each as input in modeling the atmosphere. For high resolution FTS and heterodyne observations, the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL), color-center laser (FCL) and FTS laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared and novel techniques such as intracavity laser absorption spectroscopy can provide difficult to acquire information on extremely weak absorption features. Thermodynamic properties at low temperatures can be obtained using recent innovations in pressure measuring technology. In this program, TDL, FCL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species. A vacuum station that incorporates a spinning rotor gauge, capacitance manometers, and a residual gas analyzer will be used to measure the vapor pressures of a variety of hydrocarbons and sulfides.

W93-70157
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 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 provides important insights into the nature of similar processes operative at other planets (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 characteristics 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 and Earth, including modification of transport coefficients by instability processes, solar planetary relationships, comparative planetary atmospheres, etc.

W93-70158
Ames Research Center, Moffett Field, CA.

STUDIES OF CLOUD PROCESSES ON THE OUTER PLANETS
C. R. Stoker 415-604-6490
(154-30-80)

The objective of this RTOP is to understand cloud processes on the outer planets including the vertical structure of clouds and aerosols in these atmospheres and the physical and dynamical processes responsible for discrete cloud formation. Theoretical studies and analysis of spacecraft data are performed to determine the vertical structure of clouds and how these structures are produced. 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; the life cycles of convective clouds; and the conditions required to initiate moist convection on the outer planets are being investigated. The approach of this RTOP is to use theoretical modeling and analysis of spacecraft data to study the vertical structure of clouds in the atmospheres of the outer planets and theoretical modeling to help understand how this structure is produced. We are developing numerical models of moist convective clouds and incorporating procedures to study the formation and growth of condensate clouds in the atmospheres of the outer planets. We are fitting data derived from Voyager images to radiative transfer models to help understand the vertical structure of discrete clouds on the outer planets.

W93-70159
Goddard Space Flight Center, Greenbelt, MD.

CHEMICAL KINETICS AND SPECTROSCOPY OF PLANETARY MOLECULES AND RADICALS
L. J. Stief 301-286-7529
(154-30-80)

This RTOP studies physicochemical phenomena in planetary atmospheres, comets, and related aspects of interstellar matter. Laser spectroscopy, photochemistry, reaction kinetics, and irradiation of mixtures of frozen gases are investigated and properties of atoms, radicals, molecules, and ice mixtures are measured. These experimental results are used to interpret astronomical observations and develop theoretical models. A flash photolysis-resonance fluorescence apparatus with a 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. Ice mixtures are irradiated with MeV protons and ultraviolet light; the spectra and vaporization of initially deposited and irradiated films are measured with an FTIR and a mass spectrometer.
Mars Data Analysis

W93-70162  155-04-00
Ames Research Center, Moffett Field, CA.
MARS SURFACE AND ATMOSPHERIC 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.

W93-70166  155-20-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
U.S. PARTICIPATING SCIENTIST MARS 94/96 - MARS GLOBAL GEODESY
T. C. Duxbury 818-354-4301
The objective is to solve problems related to the total science objectives of the MARS 94/96 mission using TV images, observations gathered from the Orbiters, small stations, penetrators, and balloons, and from Orbiter radio occultation and altimetry observations. This research is focused to maximize the science return from the Russian mission for the near-term and long-term U.S. Mars exploration goals and objectives benefiting...
the U.S. Strategic Exploration Initiative (SEI) Robotics missions. The scientific objectives are organized into five categories: (1) global geodesy and cartography; (2) surface photometry and thermal inertia; (3) correlative and interdisciplinary studies; (4) Phobos and Deimos; and (5) searches. The objectives within each of these categories share common analysis approaches and utilize observations from the same set of instruments. This effort will rely heavily on existing capabilities that this proposer has developed and used successfully on previous space missions including Mariner 9, Viking, Voyager and the Soviet Phobos Mission, and in supporting U.S./U.S.S.R. Joint Working Group. The experience gained from these missions would be used to support the definition, instrument development and ground testing, ground data system development, instrument flight testing, science planning, mission operations, correlative data set generations, data analysis, data management, and publications of results for all phases of the mission. To help give focus to this proposal, this investigation would work closely with and through the U.S./U.S.S.R. Joint Working Group for Solar System Exploration and its Implementation Teams for Annexes number 1, 2, 3, 4, and 15, and with the U.S. Mars Science Working Group supporting the SEI Robotic missions.

**W93-70167**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MARS 94 GRAVITY**
W. L. Sjogren 818-354-4686

The long term objectives (starts 1995) are to: (1) refine the gravity field of Mars; (2) construct and test interior structure models of Mars using the gravity data; (3) determine Mars spin pole orientation and separate the moments of inertia with a precession rate determination; and (4) determine new masses of Phobos and Deimos. The short range objectives (now through 1994) are to: (1) coordinate with the Russians on their mission design and hardware capabilities; (2) understand their efforts in this field; and (3) suggest to Russians and U.S.A. managers ways to optimize and make this experiment better within its existing bounds. The long range approach is to analyze simultaneous Doppler Radio Tracking of our Mars Observer Spacecraft and the Russian's two Mars 94 spacecraft, as well as surface eggs and balloon and to invert these data for gravity parameters. The short range approach is to: read literature from Russians; write letters to Dr. Akim in Russia; go to meetings where the mission will be discussed; and discuss Mars 94 when Dr. Akim visits JPL for MGN.

**W93-70168**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**MARS 94 WINDS**
R. A. Preston 818-354-6895

The Mars '94 balloons will be used to measure the winds in the lower atmosphere of Mars. Down-looking cameras onboard the balloon gondolas will likely be the principal instruments used in the wind measurement. Registration of pairs of overlapping images provides information on the horizontal motion of the balloons, and hence, the winds. However, measurements from other instruments are necessary to optimize the image registration process and to interpret the image pair offsets. In addition, the dynamics of the balloon-gondola system must be well understood and Doppler measurements on radio links from the balloons to the orbiters and the Earth may be important to the optimum wind determination scheme.

**Planetary Instrument Definition**

**W93-70169**
Goddard Space Flight Center, Greenbelt, MD.
**PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT**
Jacob I. Trombka 301-286-5941

The objective of the 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 exploration programs being developed in the Solar Systems Exploration Program of NASA. Specifically these tasks include instrument development in the fields of x-ray, gamma-ray, neutron, and mass spectroscopy. Both theoretical and experimental studies will be used in these investigative studies. Further studies will include investigation of the affects of the radiation environment in the operation of these detector systems. Prototype detector systems will be constructed and tested in the laboratory environment. Balloon Flights and measurements in environmental chambers will be used to test for space operation. The data obtained can then be used in the determination of detector sensitivity, calibration, and design for planetary space flight missions.

**W93-70170**
Goddard Space Flight Center, Greenbelt, MD.
**IMAGING SPECTROPOLARIMETER**
John J. Hillman 301-286-7974

The goal of this investigation is to verify the conceptual design for a novel, versatile imaging spectro-polarimeter experiment. Novel aspects of the design include the use of Acousto-Optical Tunable Filters (AOTF’s) to provide spectral discrimination and simultaneous polarization. New technology array detectors will provide spectral imaging in the Short-Wave Infrared (SWIR; 0.8 microns less than lambda less than 3 microns). A PI/DDP (Planetary Instrument Definition and Development Program) project conducted at JPL in FY92 and FY-93 generated quantitative data on AOTF performance and optimal design approaches for such an experiment. Experience gained from that project led to the preparation of the POLARIS proposal for the Cassini Orbiter. The objective is to draw upon the same base of experience and data to construct a proof-of-concept version of such an experiment and to demonstrate its capabilities by using it to make practical observations in the field. Potential platforms of this design concept include compact multispectral cameras for Discovery-class planetary missions and imaging spectropolarimeters for terrestrial remote-sensing.

**W93-70171**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ASTROMETRIC IMAGING TELESCOPE**
R. Ternile 818-354-6158

The Astrometric Imaging Telescope (AIT) is an Earth-orbiting spacecraft designed to detect and characterize extra-solar planetary systems. The two instruments of AIT detect planets both indirectly by observing the astrometric wobble of the system star, and directly by imaging the planet. The major objective of the program is to verify the research and development that will demonstrate that AIT is a technically ready and superior candidate for the first space-based mission of the Towards Other Planetary Systems program (TOPS 1). The three centers of activities are the Jet Propulsion Laboratory (JPL) program team, the Hughes-Danbury Optical Systems (HDOS) contractor support team, and the Science team (leader-E. H. Levy, Lunar and Planetary Laboratory). Major tasks of the JPL team are the mission, system, and subsystems designs, and end-to-end performance modeling. HDOS has the unique task of developing mirror metrology and fabrication techniques for the AIT optics. In addition HDOS assists JPL in the spacecraft area. The Science team provides the theoretical underpinnings for the mission, as well as state-of-the-art experience with the instrumental prototypes.

**W93-70172**
Goddard Space Flight Center, Greenbelt, MD.
**PLANETARY ORBITAL/FLYBY LASER ALTIMETER**
James B. Garvin 301-286-6565

This Planetary Instrument Definition and Development Program (PI/DDP of Code SL) investigation intends to design and build a prototype laser altimeter instrument that would meet many of the topographic data requirements recommended for a Discovery
Mission Flyby/Orbiter. Analysis of existing lunar laser altimetry (Apollo system) and lunar topography will result in improved laser system specifications. The laser altimeter will be designed to minimize weight, power, and data rate, while maintaining reliable, continuous (long-lifetime) operations. The focus will be on an entirely solid-state laser transmitter involving diode-array pumping. Fast (1 - 3 nsec) Si Avalanche Photodiode (APD) detectors and waveform digitizers will be integrated with the diode-pumped redundant Nd:YAG lasers in a simple design. An Al telescope mirror will form the heart of the receiver. A single channel spectrometer (modeled at 1.06 micrometers) will be explored. Techniques for obtaining profiles with two spatial resolutions (30 and 300m) will be studied. Link calculations will assess how easily the laser altimeter design could be enhanced for operations in asteroid orbit. This is a continuation of an RTOP which terminated in FY-91; we propose to continue the development of a Lunar Observer Laser Altimeter (LOLA) to be ready if Lunar Geoscience Orbiter (LGO) is given a new start and to develop a final Phase A report in FY-93.

W93-70173
Goddard Space Flight Center, Greenbelt, MD.
MARS LIDAR (LIDAR FROM THE MARS SURFACE AND MARS ORBIT FOR ATMOSPHERIC STUDIES)
James B. Abshire 301-286-2611
This RTOP will initiate work proposed under the Planetary Instrument Definition and Development Program (NRA 92-OSSA-06). We will investigate the design and performance of two different lidar systems to study Mars atmospheric processes. A compact lidar is being proposed for the Mars Environmental Survey (MESUR) program. This is a small system designed to view the zenith from the Mars surface and measure atmospheric backscatter profiles at 810 nm, and to measure high resolution atmospheric profiles at one location on Mars. We are also proposing a companion lidar for the Mars Aeronomy Orbiter. This lidar will use a 0.5 m diameter telescope, and will be designed to provide moderate resolution lidar profiles over the entire Mars surface covered by the spacecraft’s orbit. Backscatter profiles measured with both instruments are essential to improving understanding of the height distributions and dynamics of dust and ground-fogs in the Mars atmosphere. Both lidars utilize similar technologies in lasers with high efficiencies and long lifetimes, small Si Avalanche Photodiode (APD) detectors and low power lidar electronics. In FY-93 we will (1) prepare theoretical models of both lidar systems, (2) select the optimum laser, (3) select lightweight telescope designs, (4) design, build and test breadboard of the MESUR Lidar, (5) test the performance of both instruments, and (6) investigate tradeoffs.

W93-70174
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICRO WEATHER STATIONS FOR MARS
D. Crisp 818-354-2224
The lowest layers of the Martian atmosphere (0 to 4 km) are called the Planetary Boundary Layer (PBL). A complete understanding of the weather at these levels is essential for future robotic and manned missions to Mars because this will be the working environment. Our first opportunity to study the Martian PBL on a global scale will be provided by the Mars Environmental Survey (MESUR) Mission. That program will deploy a network of small stations on the Martian surface. An earlier opportunity to deploy a single small weather station might be offered by the 1996 MESUR Precursor Mission that is currently being considered. Existing instruments for studying meteorological processes are not well suited for this application because they are too massive, too fragile, or require too much power for deployment on the small platforms that are currently being considered for MESUR. We have therefore started to assess the feasibility and utility of miniaturized sensors for making meteorological measurements in the Martian PBL. The state-of-the-art silicon micromachining and semiconductor large scale integration technologies that are available in the JPL Micro Devices Laboratory (MDL) are being used to build and test sensors for measuring pressure, temperature, wind velocity, humidity, and aerosol abundance. These sensors could be incorporated into complete weather stations that are rugged, compact, light-weight, and require very little power. They would therefore be ideal for the MESUR Mission and other future robotic and manned missions to Mars.

W93-70175
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY HIGH TEMPERATURE SUPERCONDUCTOR BOLOMETERS
J. Brasunas 301-286-3488
This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task 06 will 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, for future planetary missions such as Uranus Orbiter, Neptune Orbiter, Pluto Flyby, Lunar and Mars missions, long-term Earth orbiting missions such as EOS and the Orbiting Planetary Telescope, and small/inexpensive missions such as the Small Explorer Series.

Solar Terrestrial SR&T

W93-70176
Goddard Space Flight Center, Greenbelt, MD.
COSMIC AND HELIOSPHERIC PHYSICS
J. F. Ormes 301-286-8801
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 remote and in-situ observations of energetic particles of galactic and solar origin in order to understand the propagation of energetic particles in the chaotic galactic and solar system magnetic fields, and to study the properties of the space plasma 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 correlation studies from a variety of spaceflight experiments such as Voyager, Pioneer, International Sun Earth Explorer (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 students’ thesis research, research associates, and occasionally a senior faculty member on leave from an academic institution.

W93-70177
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSMIC AND HELIOSPHERIC PHYSICS
R. Goldstein 818-354-0241
This RTOP consists of 6 subtasks: (1) Solar Gamma-Ray Spectroscopy (170-10-10-67, J. Ling, W. Wheaton): Demonstrate critical technology for a solar high resolution gamma ray spectrometer; (2) Solar Wind Data Analysis (170-10-10-88, M. Neugebauer): Investigations of heliospheric physics, including acceleration of the solar wind and properties of discontinuities, using solar wind data acquired by past missions; (3) Magnetospheric and Interplanetary Data Analysis (170-10-10-89, E.J. Smith).
Analysis and interpretation of Pioneer and International Sun-Earth Explorer (ISEE) vector helium magnetometer and other data; (4) Radio Analysis of Interplanetary Scintillations (170-10-10-91, R. Woo); Probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of the spacecraft radio signals; (5) Model Analysis of Heliospheric Structure (170-10-10-94, J. Ajello); Analysis of solar and interplanetary UV from interplanetary spacecraft (PV, Voyager, Galileo); and (6) Particle Simulations of the Solar Wind Termination Shock and Alfvén Wave Decay Instabilities (170-10-10-96, P. Liewer): Particle simulation codes are used to study Alfvén wave instability in the solar wind, and the effect of interstellar pickup ions on the solar wind.

W93-70178
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 approaches of this RTOP are to conduct theoretical studies aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind-Venus interaction will be conducted.

W93-70179
Goddard Space Flight Center, Greenbelt, MD.

GROUND-BASED SUPPORT OF SOLAR PHYSICS
Brian R. Dennis 301-286-7983

The major objectives of this program are listed. The first is to obtain and analyze observations of solar velocity and magnetic fields, oscillations, coronal holes, active regions, and flares at wavelengths observable from the ground. These observations complement UV, EUV, x-ray, and gamma ray observations made from NASA spacecraft, sounding rockets, and balloons. The second is 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. The last is 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 (KPVT), Arizona is supported by the Laboratory through its Southeastern Solar Station. High resolution, full disk magnetograms, and He I 10830 A spectroheliograms are routinely obtained and substantial observing time is dedicated for spacecraft support and basic research by Laboratory staff. Solar oscillations are observed at the KPVT and during campaigns in the Antarctic to study oscillations throughout the solar cycle. Collaborative instrumentation and research programs are initiated and maintained with the National Solar Observatory and other colleagues.

W93-70180
Goddard Space Flight Center, Greenbelt, MD.

THEORY, LABORATORY AND DATA ANALYSIS FOR SOLAR PHYSICS
Gordon D. Holman 301-286-4636

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

W93-70181
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SOLAR PHYSICS STUDIES
R. Goldstein 818-354-0241

This RTOP consists of two tasks. The first task is the measurement of absolute electron-ion collision parameters in solar plasma diagnostics (number 170-38-53-55, A. Chutjian), specifically the measurement of electron-ion excitation collision strengths needed to interpret solar plasma properties such as electron density and temperature and ion formation temperatures (freezing in temperature). Use is made of the electron-energy loss method pioneered at the Jet Propulsion Laboratory (JPL), using merged electron and ion beams, trochoidal energy analysis, and spatial detection of electrons using a microchannel plate. The second task concerns the variability of solar UV irradiance and its relation to the evolution of active regions and coronal activity (number 170-38-53-26, J. Pap). A study is made of the relationship between the UV irradiance variability (from the Solar Mesosphere Explorer (SME) and other spacecraft measurements) and evolution of active regions using photospheric, chromospheric, and coronal indices of solar activity.

Advanced Programs

W93-70182
Ames Research Center, Moffett Field, CA.

TELEPRESENCE FOR PLANETARY EXPLORATION
G. Briggs 415-604-0218

The objective of this RTOP is to develop and demonstrate the advanced capability to operate remote mobile robots to serve as field scientific exploration purposes, eventually on the surface of the Moon and Mars. This includes both telepresence and virtual environment capabilities. The approach is to build a prototype telepresence system integrated into an available mobile platform, a submersible remotely operated vehicle (ROV) that is used for the exploration of ice-covered lakes in the dry valleys of Antarctica (a terrestrial Mars analog). The system will emphasize telepresence vision and will evolve to include telepresence manipulation. It will begin with lakeside operations and evolve to comet operations from NASA-Ames. Initially, the system will include only telepresence and will evolve to include a virtual environment capability. The latter will be used to simplify navigation functions, to provide different view perspectives, to allow simultaneous field analysis participation, and to compensate for communications link time delays.
Solar Terrestrial and Astrophysics SR&T

W93-70183  188-41-21
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEEP OPTICAL/UV IMAGING OF QUASARS BELOW THE LYMAN LIMIT
D. Hamilton  818-354-9617

Until recently the relationship between absorption line systems found in high resolution spectroscopic studies of quasars and galaxies found in deep optical surveys have been dubious at best. We recently started a program aimed at using these complementary data sets to help provide a direct connection between galaxies found by quasar absorption line studies on the one hand and ultra-deep imaging surveys of the fields of quasars having intervening optically thick Lyman limit absorption systems which completely remove the bright quasar from the U-band on the other. The quasars observed and to be observed also have available high resolution spectroscopy, so that one has a priori knowledge of the redshifts of high redshift galaxies situated near the quasar sightline. Thus, one may image the very faint high z galaxies without contamination by the bright quasar in whose spectrum the redshift information has already been recorded. Using this method, which includes comparably deep images in two redder bandpasses, one may hope to assign redshifts to normal galaxies which are far too faint for conventional spectroscopy. This program is the first step and it is expected that we will extend the survey to quasars at lower redshifts using the WFPC-2 on the HST. The data obtained in the ground-based optical studies will aid in the planning of the WFPC-2 observations as well as contributing complementary information. We are requesting funds in order to be able to devote a fraction of time to the reduction and analysis of data already obtained and to obtaining additional data from further observing runs.

W93-70184  188-41-21
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL STELLAR INTERFEROMETRY
M. Shao  818-354-7934

The objective of this task is the development of advanced observational techniques for application to future space and lunar optical stellar interferometers, including the Orbiting Stellar Interferometer (OSI), proposed as a moderate mission for the end of this decade. The design of this instrument draws strongly on the ground-based Mark III optical interferometer, an operational Michelson stellar interferometer at Mt. Wilson, and the only instrument of its kind in the U.S. This includes not only the instrument design (configuration, aperture, etc.), but also the mission design: observing strategy, sequencing, data reduction, etc. Thus, the approach is to continue observations and data analysis with the Mark III interferometer in order to develop improved observational methods and data reduction techniques. The scientific productivity of the Mark III has improved enormously with increased observational experience; it is important to continue these observations so that those lessons can be applied to the space missions, where the learning process is much more expensive, in order to maximize their scientific productivity.

W93-70185  188-41-22
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RELATIVITY, COSMOLOGY, AND GRAVITATIONAL RADIATION
H. D. Wahlquist  818-354-2538

The objectives of these tasks are to measure a variety of relativistic effects using space technology, especially precision Doppler tracking of spacecraft, planetary radar ranging, and lunar laser ranging. The investigations include both theoretical and observational research directed towards studying the relativistic dynamics of the solar system and the detection of low frequency gravitational waves. In addition, space based experiments in relativistic gravitation are studied to evaluate their feasibility and to define their technological requirements. In FY 93, the relativity program will (1) continue studies of the continuous gravitational wave background using millisecond pulsar data and also of interferometer technology for gravitational wave detection in space; (2) develop signal processing methods for low frequency gravitational wave detection, focusing on signals expected from coalescing binaries; (3) continue coincidence theoretical research on cosmological sources of low frequency gravitational waves; (4) support observational tests of relativistic gravity theory, including geodetic precession, measurement of PPN parameters along with the Sun’s J2, and a possible time variation in the Newtonian "constant" of gravity, using planetary radar ranging and lunar laser ranging; (5) conduct a triple coincidence gravitational wave search experiment with simultaneous Doppler tracking of Mars Observer, Galileo, and Ulysses; and (6) study relativity experiments that could be performed on a Solar Probe mission.

W93-70186  188-41-23
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
George Sonneborn  301-286-3665

Space based instrument systems for astronomy 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-IR), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. Investigations are presently being conducted in two technical areas that will have substantive cost/performance payoffs. In optical materials research, major emphasis is 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.

W93-70187  188-41-24
Goddard Space Flight Center, Greenbelt, MD.
DEVELOPMENT OF UV PHOTON COUNTING GEOMETRICALLY STABLE ARRAY DETECTOR - MULTI-ANODE MICROCHANNEL ARRAY (MAMA)
Bruce E. Woodgate  301-286-5401

The objectives of this task are to continue development of the Multi-Anode Microchannel Array (MAMA) detector beyond the capabilities being used for the Solar and Heliospheric Observatory (SOHO) and the Space Telescope Imaging Spectrograph (STIS), particularly in the area of spatial resolution and dynamic range. The method of developing geometrically stable array detectors is to use a two-dimensional coded wire array behind a microchannelplate (MCP) electron intensifier. A photocathode on or near the front of the MCP converts a photon to an electron image. The MCP has sufficient gain to allow counting of individual photoelectrons. Investigations will include the use of smaller pores in the MCP's, subpixel decoding, and low resistance MCP's.

W93-70188  188-41-24
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
BAND STRUCTURE ENGINEERING ON SILICON CCDS FOR ENHANCED UV RESPONSE
P. Gnathaus  818-354-0360

The objective of this task is to demonstrate stable, broadband silicon charge coupled device (CCD) imagers with quantum efficiency at ultraviolet wavelengths (100 to 350 nm) limited only by the reflectivity of the silicon surface. The approach is to use the atomic layer control of molecular beam epitaxy (MBE) to grow
a highly doped p(+) epitaxial layer of silicon on the backside of a commercial EG&G Reticon CCD array prior to final bonding and packaging. Because the p-type charge is incorporated directly into the crystal structure of the CCD silicon substrate, this approach is inherently stable against all environmental effects. Theoretical modeling has shown that this epitaxial layer will completely eliminate the backside potential well that traps the carriers generated by ultraviolet radiation. After demonstrating the MBE-modified CCD, this task will also deposit anti-reflection layers on the modified backside to further enhance the ultraviolet (UV) response.

W93-70189
Goddard Space Flight Center, Greenbelt, MD.

UV ASTRONOMY AND DATA SYSTEMS
A. V. Sweigart 301-286-6274

The objectives are to perform theoretical and observational astronomical research of particular importance for space observations; to develop and use new instrumentation for imaging and spectroscopy of astronomical objects; to utilize imaging processing programs on Goddard computers; to develop tools and techniques which will facilitate and improve the reduction, analysis and understanding of astronomical data; to support an optical telescope observatory for testing research ideas for space projects; and to develop new instrumentation for observing astronomical objects. The approach is (1) to obtain detailed stellar evolutionary models for interpreting space observations, particularly those to be made with the Hubble Space Telescope and the Ultraviolet Imaging Telescope; (2) to perform appropriate ground and space observations to study stars, nebulae, the interstellar medium and extragalactic objects; (3) to perform theoretical studies in support of space observations; (4) to develop and use new instrumentation for imaging and spectroscopy of astronomical objects; (5) to develop and utilize imaging processing programs on Goddard computers; (6) to obtain ground-based observations in support of space observations; and (7) to develop suitable instrumentation for and maintain the NASA/GSFC 36 inch telescope.

W93-70190
Goddard Space Flight Center, Greenbelt, MD.

PHOTOPROCESSES/SPECTROSCOPY OF ASTROPHYSICAL MOLECULES AND RADICALS
J. E. Allen, Jr. 301-286-5896
(154-50-80; 154-75-80)

The principle objective of this laboratory program is to provide experimental data on photoprocesses and spectroscopy of radicals and molecules, the measurement of which can lead to a better understanding of astronomical objects and astrophysical systems. The information obtained can be used to model observations, develop interpretive/predictive models of astrophysical systems and guide the calculation of physical parameters that might otherwise be difficult to measure. In some instances the acquisition of these data requires the development or implementation of new experimental techniques. Under this RTOP physical and spectroscopic quantities such as vertical excitation energies, photodissociation and photoionization cross sections, neutral/ion product yields and oscillator strengths are measured for radicals and molecules that are particularly important in the interpretation of astronomical observations at visible and ultraviolet wavelengths. Each activity in this program presents its own set of experimental difficulties which are being addressed by a variety of techniques. Unlike stable molecules, radicals are chemically reactive which precludes the use of standard techniques and makes it difficult to acquire relevant data. To circumvent these problems, laser-depletion spectroscopy is being used to acquire vertical excitation energies for dissociative potential energy surfaces of diatomic radicals. This information is critical to the calculation of photodissociation cross sections as a function of wavelength. In related experiments photoionization cross sections for radicals are measured at single wavelengths using a fast-flow reaction system combined with an excimer laser and detection of the photoproduct by resonance fluorescence. For stable molecules, particularly triatomics, the competition between photodissociation and photoionization is examined by following the photoemission of the radical product versus the photoion yield as a function of wavelength. For larger species, such as polycyclic aromatic hydrocarbons (PAH's), electron energy loss spectroscopy is employed to obtain relative and absolute oscillator strengths from the near infrared to the far ultraviolet and x-ray regions of the spectrum.

W93-70191
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OPTICAL/UV LABORATORY ASTROPHYSICS
J. M. Ajello 818-354-2457

Laboratory Astrophysics studies of electron impact cross sections and oscillator strengths of cosmically abundant atoms, molecules and their ions are conducted at the Jet Propulsion Laboratory (JPL). The resulting data are available for analysis of Hubble Space Telescope, Extreme Ultraviolet Explorer (EUVE), Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS), ASTRO-2, and Far Ultraviolet Spectroscopic Explorer (FUSE) observations of visible, ultraviolet (UV), and x-ray 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) energy loss spectra of neutrals and ions at high electron energy resolution; and (3) lifetimes at high time resolution. The principle application of these atomic and molecular parameters are to model observations of diffuse molecular clouds, the interstellar medium, and stellar atmospheres.

W93-70192
Goddard Space Flight Center, Greenbelt, MD.

RESEARCH COMPUTING FACILITY AND CATALOGING FOR INFRARED
N. W. Boggess 301-286-6899

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' abilities 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.

W93-70193
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

INFRARED/RADIO RESEARCH
P. Wannier 818-354-3347
(188-44-23)

The objectives of this research are to carry out radio and infrared observations and analysis relating to galactic and extragalactic astronomy. The facilities used include NASA's deep space network, and the research relates to such future space missions as the Space Infrared Telescope Facility (SIRTF), a submillimeter mission (SMMM), and orbiting very long baseline interferometry (VLBI).

W93-70194
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SUBMILLIMETER ASTRONOMY
T. B. H. Kuiper 818-354-5623
(188-44-21)

The objectives of this activity are to study the interstellar medium using very high spectral resolution astronomical observations of molecular and atomic transitions. The observations will probe the physical conditions in molecular clouds, star forming regions, and circumstellar envelopes of late-type stars. Millimeter and submillimeter wave spectral lines provide diagnostics of cold molecular clouds, and of very dense, warm molecular gas as it interacts with stellar objects: protostars, T-Tauri stars, and late-type stars. Measurements of interstellar molecules at frequencies where the terrestrial atmosphere hinders observation are essential to
understand the evolution of molecular clouds and star formation. Besides the intrinsic difficulty of making such observations, this part of the spectrum has been largely unexplored because the required technologies are still in their infancy. This activity places strong emphasis on the development and use of state-of-the-art superconductor-insulator-superconductor (SIS) heterodyne receivers. One task addresses the determination of the abundance of interstellar H2O, and by implication, H2O. Airborne observations of dense molecular cloud cores are planned for 1994. The other task addresses the determination of the abundance of interstellar O2. Balloon observations will be made of a variety of molecular clouds and star forming regions in order to determine how the abundance of O2 varies as clouds evolve. These activities lend strong support to future spaceborne submillimeter wavelength astronomical missions based on high spectral resolution (heterodyne) spectroscopy. This research focuses on observations from very high mountain tops (e.g., Mauna Kea at 4.1 km) during exceptional conditions, from the NASA airborne observatory (up to 12.5 km), and from balloons (up to 42 km). A 547 GHz receiver is being constructed for use on the Kuiper Airborne Observatory in 1994. A receiver system operating at 119 GHz will be flown with the UCSB balloon-borne 1 m telescope. The receiver will have a single sideband system temperature of 100 K. The angular resolution will be 12 feet. An engineering flight is planned for June 1992.

W93-70195  188-44-23
Ames Research Center, Moffett Field, CA.
INFRARED AND RADIO ASTROPHYSICS TECHNICAL DEVELOPMENT: GROUND-BASED ASTRONOMICAL INSTRUMENT
T. L. Roellig  415-604-6426

The objective of this RTOP is to develop advanced technology for use in infrared and radio astronomical instrumentation. The technology being developed under the tasks at the NASA Ames Research Center (ARC) will be utilized at ground-based observatories in a wide variety of astrophysical studies, including imaging of planetary, galactic, and extragalactic objects. As part of this program, two instruments will be constructed, one a photometer cooled by adiabatic demagnetization refrigeration that will be used at submillimeter wavelengths (ADPRH) and the other a large format infrared camera capable of being used in the 10 and 20 micron atmospheric windows (AIRC). The approach of this RTOP is to build on existing technology and facilities here at NASA-ARC, extending the technology beyond the developmental stage to allow it to be employed in useable, state-of-the-art, astronomical instrumentation.

W93-70196  188-44-23
Goddard Space Flight Center, Greenbelt, MD.
INFRARED, SUBMILLIMETER, AND RADIO ASTRONOMY
N. W. Boggess  301-286-6989

The scientific objective of this program is to provide a better understanding of the current state and evolution of the universe as a whole and of specific objects within it. This is achieved by making, analyzing, and interpreting observations at wavelengths from 1 micron to 1 mm and at a wide range of spectral resolving powers. Since atmospheric opacity and emissivity prohibit it 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 maximum 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.

W93-70197  188-44-24
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEVELOPMENT OF 1036 GHZ RECEIVER FOR ASTRONOMY AND NEAR IR IMAGING AT PALOMAR
M. A. Frerking  818-354-4902

This RTOP covers two tasks: development of technology for 1000 GHz heterodyne capability and the development of a near IR imaging camera for use at the Palomar Observatory. The original objective of the first task was to demonstrate in the laboratory a heterodyne receiver operating above 1000 GHz using components baselined for SMIM superconductor-insulator-superconductor (SIS) tunnel junction mixers. Due to lack of funds, that objective was desigated to address key technical issues associated with high frequency SIS heterodyne mixer operation. In particular, superconducting integrated tuning elements to better couple radiation into the mixers are being studied. In addition, parameters of the superconducting distributed circuit elements, such as loss and phase velocity, are being characterized for frequencies greater than 500 GHz. A parallel task to develop a ground-based imaging source that was part of the original proposal is being carried out independently at the University of Massachusetts. Two papers have been accepted for publication during the last year based on this effort. The second task provides partial support for a number of observational programs at Palomar in infrared astrophysics: the formation of solar-type stars, the luminosity function of high mass stars in giant molecular clouds, the energetics of Infrared Astronomical Satellite (IRAS) bright galaxies, a search for counterparts to Lyman alpha absorbing systems seen toward distant quasars, and the search for ultra-luminous infrared objects at redshifts greater than 2. These programs are being carried out with an infrared camera at the prime focus of the Palomar 5-m telescope. Last year we upgraded the camera by replacing its Rockwell-HIRES 256 x 256 array with a lower noise NICMOS III 128 x 128 array. We have had three successful runs using this array. We are now upgrading the camera again to incorporate a Near Infrared Camera and Multi-Object Spectrometer III (NICMOS III) 256 x 256 array purchased with support from this grant as well as from internal JPL funding. Support is requested to assist with laboratory testing of the new array, and for new optical elements to improve the quality of the images over the larger field enabled by the new 256 x 256 array. Three papers have been accepted for publication during the last year based on this effort.

W93-70198  188-44-53
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SIMULATIONS OF COMPACT RADIO SOURCES
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 region of the spectrum with theoretical work to improve the understanding of hydrodynamical and magnetohydrodynamical processes in radio sources. In FY-93, these programs will use our magnetohydrodynamic (MHD) jet and accretion disk simulation code, recently ported to the new Caltech Intel Touchstone DELTA parallel supercomputer, to perform an intensive study of magnetic accretion disks and their potential for producing, collimating, and accelerating jets, with special emphasis on extremely CPU- and data-intensive calculations on the DELTA. We are also embarking on the creation of an entirely new field of numerical astrophysics which will attack implicit, multi-dimensional problems, such as thick accretion disks and rotating stars, using the Finite Element Method. This latter method has been used extensively in the field of structural engineering to solve similar problems.

W93-70199  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 magnetohydrodynamic fluid problems, multi-dimensional particle problems, and complex chemistry and radiative transfer situations. This effort makes effective use of the advanced computational facilities at Ames.

W93-70200 188-44-53
Goddard Space Flight Center, Greenbelt, MD.

THEORY AND MODELING: INFRARED, SUBMILLIMETER, AND RADIO
N. W. Boggs 301-286-6989

The scientific objectives of this program are 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 conducting theoretical and analytical studies, including sophisticated modeling, in which the emphasis is on examining effects in the wavelength range 1 micron to centimeters. Tools and techniques which will facilitate and improve theoretical analysis and enable maximum insight into the understanding of astrophysical data are being developed.

W93-70201 188-44-57
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LABORATORY ASTROPHYSICS
H. M. Pickett 818-354-6861

The objective of this work is to make measurements and provide laboratory data in support of NASA's missions in astrophysics, particularly those missions using molecular signatures in the infrared, far infrared, submillimeter and microwave regions of the spectrum. In one thrust of this research, primary spectral data is obtained in the laboratory, and theoretical models based on this and other data are cataloged and made available to the general astrophysics community. These cataloged results are then used for both planning and interpreting observations with either airborne or spaceborne instrumentation. A second thrust of this laboratory astrophysics work involves measurement of ion-molecule reactions and their interpretation. Reaction association reactions are a class of ion-molecule reactions important in the evolution of interstellar gas clouds. The aim is to study these reactions in the laboratory and develop methods of predicting the importance of similar reactions that are not measurable in the laboratory. A third thrust of this work involves the study of infrared emission from polycyclic aromatic hydrocarbons (PAH's). The focus is on optimizing laser desorption sources for PAH's with detection of ionized PAH spectra.

W93-70202 188-44-57
Ames Research Center, Moffett Field, CA.

PROPERTIES OF INTERSTELLAR PAH'S
L. J. Allamandola 415-604-6890

The objective of this RTOP is to understand why free, molecular sized, polycyclic aromatic hydrocarbons (PAH's) 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 of interstellar clouds, 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 PAH's in the forms in which they are likely to exist in space: ions, radicals, neutral species, and clusters. Spectroscopic properties of these unique species are particularly important to know since all telescopic data pertaining to this problem are spectroscopic. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further the understanding of the roles of PAH's in astrophysics. Experiments are underway in the laboratory in which PAH's are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found.

W93-70203 188-44-57
Goddard Space Flight Center, Greenbelt, MD.

LABORATORY ASTROPHYSICS
J. Nuth 301-286-8467 (152-12-40)

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 SIRTF and SOFIA; and (5) to understand photodissociation processes for molecules and radicals in circumstellar and interstellar environments. Data required to achieve the above objectives will be obtained using a variety of experimental techniques and equipment. In particular, objectives (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 systems, a UV-visible spectrometer and an FTIR spectrometer. Objective (4) requires use of a low-T cryostat, FTIR, and a 1 MeV proton accelerator. Objective (5) requires the use of UV light sources and tunable dye lasers.

W93-70204 188-46-01
Ames Research Center, Moffett Field, CA.

THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STEellar OBJECTS (QSOs)
F. C. Witteborn 415-604-5520

The objective of this RTOP is to understand the origin of the continuum spectra of compact, luminous objects such as active galactic nuclei. An optically thick, relativistic outflow is believed to arise in the core of these objects. The evolution of the distribution functions of the photons and pairs in this core is followed from an arbitrary start until a characteristic spectrum is reached or until the spectrum freezes out. The emergent electron-positron photon spectrum is compared directly with observations. The interaction of the emergent electron-positron pair wind or jet is modelled and its predicted radiation is compared with observations. The approach of this RTOP is to model interaction processes which are likely to be important to the spectrum: pair production, pair annihilation, Compton scattering and bremsstrahlung. In addition, synchrotron emission is important in a strongly magnetized plasma. The research will be extended by modelling the dynamics and spectrum of the pair jet which emerges from the optically thick core and can be observed directly in radio-string objects.

W93-70205 188-46-01
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 astronomy, energetic particles, and cosmological studies. MuliisiUite satellite examples, such as those of Ariel 5, OrbiUg Solar Observatory (OSO) 6, High Energy Astronomy Observatory (HEAO) 1 and HEAO 2 provide a basis of information which for many x ray sources remains complementary to the results of recent missions such as European X ray Observatory Satellite (EXOSAT) and Ginga, and upcoming missions such as Roentgen Satellite
photons, and sensitivity, including the study of techniques to build resolution, including techniques to concentrate on higher energy
several approaches are being explored to improve angular
now being directed towards drift chambers. At the same time,
improvements in the track imaging chamber systems are continuing,
been pursued and other approaches to detector systems are now
of a large high energy telescope using digitized spark chambers.

In FY-93, analysis will be completed on the balloon flight data
image reconstruction was demonstrated. The performance of a
cooled by a Stirling cycle refrigerator
the germanium detectors to about 80 K for many years without

The objectives of this task is to
designing and fabricating
CCD's at photon

The technical objective is to develop the most appropriate
detector systems for the observation of astrophysical sources
of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system 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 will be developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma-ray bursts. It was installed at Kitt Peak National Observatory and operation has begun.

The objectives of this effort are to develop new instrumentation to perform high resolution spectroscopy and imaging of celestial gamma-rays in the 0.01 to 10 MeV range and 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.

The objective of this task is to develop, in a joint effort with Pennsylvania State University (PSU), 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 an instrument which will acquire energy-resolved x-ray images of astronomical sources from the NASA/CONAE satellite, SAC-B. This task will be accomplished by designing and fabricating CCD's which combine proven features and new improved features to provide high sensitivity at photon energies of 0.3 to 2.0 KeV with very low noise (approx. 0.5 electrons, rms) signal readout.

The Goddard Space Flight Center (GSFC) X-Ray Astronomy Group has repeatedly made major technological breakthroughs that have qualitatively improved capabilities for spectroscopy in the x-ray band. These advances, from proportional counters to x-ray calorimeters to broad-band x-ray optics, have all had their origins in our Space Research and Technology program. We intend to develop a broad-based program to continue this development both by enhancing current technologies and by developing promising new technologies. We plan a systematic program to develop techniques to approach the intrinsic spatial resolution of conical foil x-ray optics, whose high filling factor and flat-field characteristics are powerful advantages for many investigations. We plan enhancements in x-ray calorimeters, including new technologies for thermometers and absorbers, which may improve their energy resolution by an order of magnitude. With a view farther into the future, we plan to develop Josephson junctions as x-ray detectors. There is the promise of detectors with the spatial resolution of charge coupled devices (CCD’s) and the spectral resolution of
current calorimeters. A key to our progress in detector and mirror technology has always been and will continue to be the ready availability of the proper calibration facilities. Our current capabilities are becoming inadequate, and we are investigating appropriate upgrades. Finally, we plan the first astronomical observations using x-ray calorimeters in a series of rocket flights. The first flight will provide the first truly high resolution spectroscopic observation of the soft x-ray background. It will test in a fundamental way our understanding of the interstellar medium and, by constraining models for the extragalactic x-ray background, will contribute to our understanding of the evolution of active galaxies and quasars.

W93-70211 188-78-01
Goddard Space Flight Center, Greenbelt, MD.

INTEGRAL MISSION DEFINITION STUDY
Sam E. Bergeson-Willis 301-286-5344

The objective of this effort is to study mission issues relevant to flying a high resolution germanium detector on a European spacecraft for gamma-ray spectroscopy. The INTEGRAL Mission was accepted for final competition by ESA in FY-92 and the scope of this RTOP has, therefore, been reduced to exclude farther consideration of the Nuclear Astrophysics Explorer Mission. The specific goals for FY-93 are in two parts. First, from October 1992 to June 1993, the efforts involve working with the American and European gamma-ray science communities, ESA, and their contractors to develop and demonstrate the feasibility of all launch vehicle, spacecraft, instrument module, instrumentation, and science aspects of the INTEGRAL Mission and their associated costs. The object is to gain selection as the ESA M2 Mission in June over three competing missions. After selection in June, the objective will be to prepare to respond to an Announcement of Opportunity for the spectroscopy portion of the mission.

W93-70212 188-78-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

GRAVITY WAVE MISSION DEFINITION STUDY
R. W. Hellings 818-354-3192

The purpose of this research is to investigate technology issues for missions to detect gravitational waves. Recent advisory panels have identified gravitational wave detection as the number-one goal of experimental gravitation in space. In the last year, we have identified a descoped version of a laser interferometer gravitational wave antenna that seems to require technology that can be developed in the near term (4 to 6 years). Several aspects of this mission need to be studied to refine technology requirements or to demonstrate where the technology is already available. These will be the particular goals for the current year.

W93-70213 188-78-41
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OPTICAL INTERFEROMETRY IN SPACE
M. D. Rayman 818-354-2544

The primary objective of this RTOP is to define an astrometric interferometry mission responsive to the recommendations of the Astronomy and Astrophysics Survey Committee for launch early in the next decade. The targeted wide-angle astrometric accuracy is 3 to 30 microarcseconds on objects as faint as 20th magnitude. The concept is based on the Orbiting Stellar Interferometer (OSI) architecture. In FY-91, basic mission and flight system designs were formulated, science performance was predicted, and preliminary cost estimates were developed for a mission design. In FY-92, the lessons learned in the first point design were used to develop a lower cost mission option. In addition, further definition was developed on the instrument and the flight subsystems. In FY-93, the mission option developed in FY-92 will be used as a basis for conducting trade studies with emphasis on continuing to reduce the cost and complexity. A preliminary operational scenario will be developed and used in these subsystem trades, as well as in modeling and requirements definition. Because of the very tight requirements on the optics and the optical paths through the spacecraft, thermal and structural models will be developed and used to estimate the performance in the presence of the predicted disturbance environment. These results will be used to improve the confidence in the performance predictions, and they will be fed back into the instrument and flight system designs with the objective of continuing to develop a low-cost design with high quality science return. A key technology challenge for this mission is the development of relative metrology systems with subnanometer-level accuracy and absolute metrology systems with 20 micron accuracy. In FY-92, relative and absolute metrology testbeds were designed, developed, and tested. In FY-93, these testbeds will be used in an effort to demonstrate 1 nm accuracy for a one-dimensional relative metrology system and 50 micron accuracy for an absolute metrology system (the required relative performance will be demonstrated in FY-94). In addition, the design for articulated laser beam launchers will be developed and construction of a working system will be initiated in the laboratory. The Space Interferometry Science Working Group (SISWG) will be supported in its process of deciding on the preferred candidate for the Astrometric Interferometry Mission, and directives from the SISWG will be incorporated into the technical work undertaken during the year.

W93-70214 188-78-44
Ames Research Center, Moffett Field, CA.

INTEGRAL MISSION DEFINITION STUDY
R. W. Hellings 818-354-3192

The objective of this effort is to study mission issues relevant to flying a high resolution germanium detector on a European spacecraft for gamma-ray spectroscopy. The INTEGRAL Mission was accepted for final competition by ESA in FY-92 and the scope of this RTOP has, therefore, been reduced to exclude farther consideration of the Nuclear Astrophysics Explorer Mission. The specific goals for FY-93 are in two parts. First, from October 1992 to June 1993, the efforts involve working with the American and European gamma-ray science communities, ESA, and their contractors to develop and demonstrate the feasibility of all launch vehicle, spacecraft, instrument module, instrumentation, and science aspects of the INTEGRAL Mission and their associated costs. The object is to gain selection as the ESA M2 Mission in June over three competing missions. After selection in June, the objective will be to prepare to respond to an Announcement of Opportunity for the spectroscopy portion of the mission.

W93-70215 188-78-44
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ASTROTREQ 21
R. Capps 818-354-0720

The objective of this RTOP is to define an astrometric interferometry mission responsive to the recommendations of the Astronomy and Astrophysics Survey Committee for launch early in the next decade. The targeted wide-angle astrometric accuracy is 3 to 30 microarcseconds on objects as faint as 20th magnitude. The concept is based on the Orbiting Stellar Interferometer (OSI) architecture. In FY-91, basic mission and flight system designs were formulated, science performance was predicted, and preliminary cost estimates were developed for a mission design. In FY-92, the lessons learned in the first point design were used to develop a lower cost mission option. In addition, further definition was developed on the instrument and the flight subsystems. In FY-93, the mission option developed in FY-92 will be used as a basis for conducting trade studies with emphasis on continuing to reduce the cost and complexity. A preliminary operational scenario will be developed and used in these subsystem trades, as well as in modeling and requirements definition. Because of the very tight requirements on the optics and the optical paths through the spacecraft, thermal and structural models will be developed and used to estimate the performance in the presence of the predicted disturbance environment. These results will be used to improve the confidence in the performance predictions, and they will be fed back into the instrument and flight system designs with the objective of continuing to develop a low-cost design with high quality science return. A key technology challenge for this mission is the development of relative metrology systems with subnanometer-level accuracy and absolute metrology systems with 20 micron accuracy. In FY-92, relative and absolute metrology testbeds were designed, developed, and tested. In FY-93, these testbeds will be used in an effort to demonstrate 1 nm accuracy for a one-dimensional relative metrology system and 50 micron accuracy for an absolute metrology system (the required relative performance will be demonstrated in FY-94). In addition, the design for articulated laser beam launchers will be developed and construction of a working system will be initiated in the laboratory. The Space Interferometry Science Working Group (SISWG) will be supported in its process of deciding on the preferred candidate for the Astrometric Interferometry Mission, and directives from the SISWG will be incorporated into the technical work undertaken during the year.

W93-70216 188-78-60
Ames Research Center, Moffett Field, CA.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)
G. W. Thorley 415-604-5917

The objectives 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
Planetary Astronomy

W93-70217 196-41-03
Lyndon B. Johnson Space Center, Houston, TX.

OBSERVATIONS OF THE MOON, MERCURY, AND PRIMITIVE ASTEROIDS
A. E. Potter 713-483-5061

This RTOP has two general objectives: (1) to understand the exospheres of Mercury and the Moon by study of the sodium and potassium atmospheres of these objects via high-resolution spectroscopy and imaging with ground-based telescopes (the observed abundance and spatial distribution of these atmospheres is interpreted through theoretical modeling and radiative transfer calculations); and (2) to study the composition of primitive (C, P, D, F) asteroids through the study of their spectral properties, and to apply the acquired knowledge to the understanding of the formation conditions throughout the outer part of the main asteroid belt and the outer belt. In particular, the onset of aqueous alteration at various heliocentric distances will provide information about formation conditions. The approach includes: obtaining new narrowband charge coupled device (CCD) reflectance spectra of main-belt and outer-belt primitive asteroids in the 0.35 to 1.0 micron spectral range; studying these spectra for fine absorption features which have been correlated with iron oxide features seen in terrestrial phyllosilicates and carbonaceous chondrites; and studying the shape and depth of these features and correlating these data with heliocentric distance to obtain information about the mineralogical products of aqueous alteration at these heliocentric distances.

W93-70218 196-41-50
Goddard Space Flight Center, Greenbelt, MD.

GROUND-BASED INFRARED ASTROPHYSICS
Donald E. Jennings 301-286-7701
(186-44-57; 154-50-80)

The scientific objective of this program is to obtain infrared spectra of planets with a combination of the highest possible sensitivities and the highest 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(exp -1) resolution. A new spectrometer has been constructed to take advantage of the improved sensitivity available with modern detector arrays. A large cryogenic grating disperses the spectrum onto a 10 x 50 element array. This instrument yields another order-of-magnitude improvement in sensitivity.

W93-70219 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; preparation of the facility for the upcoming pass of ULYSSES over the heliospheric poles is a key for future planning. Funding under this RTOP provides support for the operation of the observatory only. However, analysis of research results is funded by other resources. 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, and other phenomena. Most spectacular, disconnection events (DE's) of the plasma tail were discovered in JOCR images of comet Kohoutek and have been plausibly linked to sector boundary crossings and magnetic reconnections; a catalog of DE data consisting of 72 DE's in 29 comets between solar latitudes. The DE results on sector structure may possibly represent the only actual probes of the IMF sector structure at high latitudes (until the ULYSSES mission). Recently, studies of computed (potential) coronal magnetic fields have given support to the DE comet results. DE's, helical waves, and prominent turning tail rays are seen on many of the images of Halley's Comet taken at JOCR (and elsewhere). Over 100 photographic plates of comet Bradfield (1987's) were obtained during the period August 1987 through December 1987 including a spectacular disconnection of the ion tail that lasted for at least five nights centered on October 20, 1987. A CCD system with both narrow band IHW comet filters and broadband BVRI filters attached to the 16 inch f/35 telescope has been added to the complement of instrumentation available at JOCR. A second CCD has been placed behind a 300mm lens and comet filters to provide additional wide-field imaging capability of bright comets, including Austin and Levy in 1990. Especially significant was a series of H2O vapor exposures of Austin on May 21, 1990 which showed the development of large angular excursions in the tail, tail ray development, and disconnection activity. These digital images have been deposited on video and in a digital format. Calibration of the CCD/filter systems and automation of the 16 inch telescope for tracking of solar system objects has been completed.
Life Sciences SR&T

W93-70223 199-02-31
Lyndon B. Johnson Space Center, Houston, TX.

CLINICAL MEDICINE TECHNOLOGY WATCH
C. W. Lloyd 713-483-7120

Development of instrumentation technologies and protocols for Space Medicine Programs as an on-going task is required as the Allied Health Professions evolve. During lunar/Mars missions, immediate return to Earth will not be possible; therefore, appropriate medical care capabilities will have to be an integral part of these programs. Current Space Station Freedom (SSF) mission scenarios describe up to 90-day missions for a crew of four people. For the SSF Program, the Medical Sciences Division is developing a modular in-flight Care Health System (CheCS), which is comprised of three components: Health Maintenance Facility (HMF) which will provide the in-flight medical capabilities, the Exercise Countermeasures Facility (ECF) which will provide the capabilities to counteract musculoskeletal and cardiovascular deconditioning, and the Environmental Health System (EHS) which will be responsible for the monitoring of the quality of the SSF internal environment. The specific objectives of CheCS are outlined in JSC 31013. The unique challenge of providing medical capabilities for SSF and future Space Medicine Programs will continue to require development of low weight, low volume, highly automated medical care based as much as possible on terrestrial medical tenets and equipment.
mass, energy or velocity, and direction of travel. These models are being used: (1) to develop more accurate assessments of astronaut radiation exposures and body self-shielding factors; and (2) to analyze and understand the results of radiation biology experiments.

W93-70226
Lyndon B. Johnson Space Center, Houston, TX.

RADIATION HEALTH
C. Yang 713-483-5583
The space radiation environment is a milieu of trapped ionizing particles, protons, and electrons from solar particle events (SPE) and high energy galactic cosmic radiations (GCR). This RTOP is devoted to long-term research to determine the characteristics of the space radiation environment and to study its health risks for manned space operations. Currently available information is insufficient for low inclination Space Shuttle orbits. However, missions involving polar orbits, a permanently manned Space Station, manned sorties to geostationary orbit, lunar bases, and piloted Mars missions require a more thorough understanding of the interaction of radiation energies, charges, fluxes, and the long-term biological effects. Based on knowledge obtained from previous research under this RTOP, exposure to ionizing radiation may be a limiting factor in both mission and career durations for space workers.Shielding considerations, based upon radiobiological responses, may influence significantly the detailed design and total mass of a spacecraft, especially for protection from solar particle events. To provide timely solutions to these problems in the mission planning stage, the underlying research must be conducted now. A plan is presented for research in specific areas of radiobiology and radiation dosimetry. Specific attention is given to the effects of high energy heavy ions of space since the problem is unique to NASA. A coordination effort with other NASA programs and programs of related government agencies augments the information required by NASA for radiation protection of astronauts.

W93-70227
Lyndon B. Johnson Space Center, Houston, TX.

ENVIRONMENTAL HEALTH
J. M. Waligora 713-483-7200
The objectives of the Environmental Health RTOP are to support: (1) research involving specification, measurement, and control of the man-made internal environment in the manned spacecraft and habitats; (2) research and technology assessment essential for the definition, development, and updating of the Space Station Environmental Health Subsystem; and (3) 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; provide the technology to detect compliance with these requirements; and finally, define the mechanism of response of the body to deleterious environmental factors and investigate potential countermeasures.

W93-70228
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACEx RADIATION
G. A. Nelson 818-354-4401
(106-20-04)
The objectives of this RTOP are to delineate the genetic and developmental effects of high linear energy transfer (LET) radiation (similar to that found in space as cosmic ray or HZE particles) and to understand how cellular repair systems process radiation induced damage. We are using the simple animal C. elegans as a model system in radiobiology studies conducted at JPL and the Lawrence Berkeley Laboratory BEVALAC accelerator. Autosomal visible and lethal mutations and chromosome aberrations leading to formation of nucleoplasmic bridges and duplications of X chromosome segments are being analyzed to understand particle-induced genetic lesions. The kinetics of production of these various lesions have been investigated as functions of particle parameters such as LET, charge, and velocity. The structures of ion-induced lethal mutants are under investigation by genetic crosses, deletion mapping, and, in the case of unc-22 mutants, by DNA hybridization techniques. Modification of mutagenesis and chromosome aberration kinetics is being tested using radiation sensitive rad mutant strains which are associated with the activities of different DNA repair pathways. Molecular biology methods are being employed to establish the existence of nuclease genes homologous to human excision repair loci. The nature of these repair systems will be further investigated by the isolation of new radiation sensitive and nuclease metabolism mutants and construction of specialized strains. The effects of track structure and free radicals are being probed by variation of ion velocity, the partial pressure of oxygen, the use of free radical scavengers, and electron spin resonance methods. Finally, we are exploring the potential alteration of gene expression using transgenic worms containing genes linked to a heat shock promoter.

W93-70229
Lyndon B. Johnson Space Center, Houston, TX.

SPACE HUMAN FACTORS BEHAVIOR AND PERFORMANCE
B. J. Woolford 713-483-3701
The objectives of this RTOP are to: (1) quantify human performance capabilities and limitations and move toward quantification of man-machine engineering data, both on the ground and in flight; (2) 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) collect, organize, and make accessible data on space human factors so the innovative steps may be taken toward creating better interfaces in future vehicles and habitats. The approach is to: (1) implement a series of continuing tasks to identify and implement practical instrumentation packages for acquiring quantitative man-machine engineering data in various gravitational fields and under actual flight conditions; (2) continue those efforts currently defined that lead toward definitive design requirements for use as inputs to an automated crew station design; and (3) pursue feasibility studies of promising new crew interface items and methods.

W93-70230
Lyndon B. Johnson Space Center, Houston, TX.

BEHAVIOR AND PERFORMANCE RESEARCH
Albert W. Holland 713-483-8482
(199-22-06; 199-06-12)
This RTOP addresses the human behavior and performance issues inherent in extended-duration space missions. As space missions increase in duration and complexity, issues such as individual adaptation to extended confinement, performance of isolated teams, cognitive readiness, motivation maintenance, and psychophysiology become salient. The RTOP focuses upon individual and team selection and training, as well as improved mission design, as principal strategies for maintaining and enhancing crew psychological health, safety, and performance. The approach is to conduct applied behavioral research whose results can be rapidly and effectively utilized by space operations to resolve salient human issues. The RTOP objectives are to: (1) determine the critical factors which affect behavior and performance in spaceflight and understand the underlying mechanisms, (2) develop methods of effectively assessing behavior integrity, (3) develop and verify procedures and strategies for assessing, maintaining, and enhancing crew health and performance; (4) utilize mission testbeds and field analogs as appropriate to maintain a knowledge base consistent with the requirements of NASA Space Programs; and (5) generate program-specific deliverables such as guidelines and standards in crew training, selection, infighting support, and mission operations.

W93-70231
Ames Research Center, Moffett Field, CA.

BEHAVIOR, PERFORMANCE AND HUMAN FACTORS
M. M. Connors 415-604-6114

47
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Research objectives of this RTOP are: (1) understand individual/group, organization/management, 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; (3) interpret and apply research results to specific problems (current or anticipated) in aerospace operations; (4) understand the role of visual and auditory cues in perception; and (5) evaluate the use of advanced simulation techniques in preflight (or simulated) on-flight hand-eye coordination, perception, vestibular-ocular control, and locomotion and posture, and to understand the neurochemical, physiological, and anatomical bases of adaptation to these environments. Also of interest are the effects of atypical gravitational forces on neonatal development and the occurrence of 'critical periods.' Knowledge gained from the research may be used as the basis for behavioral and/or neuropharmacological countermeasures to minimize specific functional deficits that astronauts would otherwise suffer.

W93-70232
Lyndon B. Johnson Space Center, Houston, TX.

GENERAL BIOMEDICAL: CENTER AND HEADQUARTERS
SUPPORT
F. T. LaRochelle 713-483-8719

The objective is to understand the mechanisms and development of countermeasure options for the impaired thermoregulation in deconditioned subjects during exercise; (2) the effect of gravity on the regulation of circadian rhythms, and (3) the endocrine and fluid and electrolyte mechanisms involved in the adaptation to head-down bedrest and the response to pharmacological agents. Results will contribute to EVA suit technology requirements, to the understanding of the effect of gravity on homeostatic mechanisms, and to the development of safer and more effective therapeutic options.

W93-70236
Lyndon B. Johnson Space Center, Houston, TX.

BONE MINERAL METABOLISM AND MUSCLE PHYSIOLOGY
M. Jaweed 713-483-7269

The overall goal of the RTOP is to understand the physiological changes in the musculoskeletal system of astronauts, occurring due to long-term exposure to microgravity. The research efforts are directed towards elucidating the pathogenesis associated with muscle atrophy and bone demineralization and to develop safe and effective physical, physiological, nutritional, pharmacological, and biomechanical countermeasures to maintain the musculoskeletal integrity and function. This 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 geared to maintain functional capacity of the astronauts and to develop safeguards against potential hazards both in 0-g and 1-g environments. The program entails a comprehensive evaluation of bone demineralization and muscle atrophy and their prevention in human subjects. Primarily, non-invasive or semi-invasive biochemical, histochemical, physiological, nuclear magnetic resonance (NMR), tissue culture, and radiological methods will 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), BMAC, EMTC, and MTC missions.
The long-range goal is to understand the process of muscle weakness and wasting in space in order to reduce or prevent their occurrences 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 is entirely on bone, muscle, and connecting ligaments and tendons. However, there is necessarily an overlap with other biomedical areas, especially cardiovascular, endocrine, and neural 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. A basic science approach is primarily used 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 essential 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 zero gravity environment. Current preventive measures included in this research are exercise, centrifugation, nutrition, and pharmacologic agents.

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. 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. The plan for fiscal year 1993 is to complete development and validation of the muscle volume measurement method and then to carry out a technology transfer strategy that would make the method accessible to other NASA Center users. This strategy involves implementation of the method on a PC-based stand-alone computer, in place of the mini-computer currently in use.

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. The focus of this RTOP is to determine the molecular mechanisms which are responsible for the influence of gravity on cellular function. This will include the examination of both direct effects of gravity on the cellular machinery (e.g., signal transduction pathways, cytoskeletal structures) and indirect or environmental effects (cell dispersion effects, transfer of nutrients or effector molecules, etc.). Several tasks examine the fundamental mechanisms of cellular systems which exhibit a sensitivity to the space flight environment or a related environmental factor (e.g., stress, hypokinnesia). The understanding of these mechanisms at the cellular and molecular level may provide a basis for the analysis of space flight induced physiological changes within higher organisms.

The objectives of this program are to further our understanding of the effects of altered gravities on mammalian cells and the mechanisms of the cellular responses. Gravity modulation of cell behavior will be studied in the context of growth factor responsiveness. Various indices of cell behavior will be studied, including changes of the internal supporting architecture of the cell, alterations of proliferation potential, and modification of genetic information utilization. The approach of this program centers on the measurable changes in response that occur following the exposure of viable cells to altered gravities. The model system chosen comprises cells of the dermis and epidermis (skin). Centrifugation and clinostat treatment will be used as laboratory equivalents of hyper- and microgravity.

Living systems have evolved in a gravitational field and are regulated by function within tightly controlled limits. Asymmetries in the environment (including presumably gravity) result in disturbances in these regulatory mechanisms to which living systems adapt or evolve (or if not, become extinct). These regulatory mechanisms, in their broadest sense, involve those controlling the physiological baseline, characterized by circadian and other rhythmic periodicities, and the ability to respond appropriately to stimuli, controlled by negative feedback networks. These in turn depend at the organ level on the regulation of calcium-dependent stimulus secretion coupling and at the cellular level on transcription/translation mechanisms. The objective of the Integrative Biology RTOP is to address key issues that will lead to an understanding of how gravity affects these mechanisms regulating homeostasis, adaptation, and the ability of living systems to respond to internal and external signals. Research will focus on the role of gravity in circadian and homeostatic regulation. While study of the physiological effects of hypogravity is primary, ground-based hypergravity studies will remain an essential part of the program.

The structural Biosystems Research Program will address key issues that will lead to an understanding of the biological processes regulating structural support systems as well as the role of gravity in modulating these processes. This program sponsors research focused on the influence of gravity primarily on musculoskeletal cell structure and function and on the use of altered gravity as a probe to explore the plasticity of the musculoskeletal system. The structural biosystems program supports research which employs in vitro and animal model systems to investigate structure and function from the subcellular to organismic level. The program takes advantage of both actual and simulated spaceflight environments to study physiological effects of hypogravity. A major emphasis of the program is to use hypogravity to understand the role of gravity in modulating mechanisms and responses of the musculoskeletal system. Multiple
approaches are required to understand how structural tissues are created for support of organisms (cellular, invertebrate, and vertebrate systems) 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. The loaded and unloaded musculoskeletal system of growing rats will be studied to characterize the development of matrix in muscle and bone and mineral composition of bone.

W93-70243
Ames Research Center, Moffett Field, CA.

FLIGHT RESEARCH
C. E. Wade 415-604-3934

The objectives of this RTOP are to support research directly related to flight experiment and to support scientific studies and planning activities in gravitational biology.

W93-70244
Ames Research Center, Moffett Field, CA.

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. The approach to this RTOP will be to conduct engineering studies for improvements to life sciences laboratory equipment hardware in order to make cost efficient second generation equipment.

W93-70245
Lyndon B. Johnson Space Center, Houston, TX.

CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES
Everett K. Gibson, Jr. 713-483-6224

The goal of this study is to investigate the elemental and molecular compositions of volatiles and the chemical state of carbon present in interplanetary dust particles (IDP’s). 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 along with obtaining accurate and reliable bulk carbon abundances in a group of IDP’s and obtain spatial distribution, the phase compositions and proportions, and the degree of crystallinity of the carbonaceous material. 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 IDP’s will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

W93-70246
Ames Research Center, Moffett Field, CA.

COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-604-5999

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; and (3) analyze U-2 aircraft-collected interplanetary dust particles and long duration exposure facility (LDEF) impact crater residues for biogenic and inorganic elements and characterize their phase structures.

W93-70247
Ames Research Center, Moffett Field, CA.

PREBIOTIC EVOLUTION
S. Chang 415-604-5733

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 the physical environments of those bodies, 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.

W93-70248
Ames Research Center, Moffett Field, CA.

THE EARLY EVOLUTION OF LIFE
D. J. DesMarais 415-604-3220

The objective of this RTOP is to understand the nature and evolution of primitive organisms and to relate such evolution to those forces which guided 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 as an approach to understanding life elsewhere in the Universe. Two repotistions 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 the 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.

W93-70249
Ames Research Center, Moffett Field, CA.

SOLAR SYSTEM EXPLORATION
G. C. Carle 415-604-5765

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 toward development of the gas chromatographic approach since it is now proven to be among the most effective means for measuring complex, gaseous mixtures. Improvements in gas chromatographic techniques, e.g., multiplex chromatography, and components, e.g., detectors and columns, will be rigorously explored. Other techniques and experiments for extraterrestrial studies related to the understanding of the origin of life will be investigated and developed for other flight opportunities as appropriate, e.g., Space Station and lower-Earth orbiters.

W93-70250 199-52-54
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXOBIOLGY INTACT CAPTURE TECHNOLOGY DEVELOPMENT
P. T. Tsou 818-354-8094

The ultimate objective of our endeavor is to return to Earth intact particles for detailed laboratory analyses. Unlike destructive dust capture techniques, intact capture can preserve the chemistry, biogenic elements, and petrology of the captured particles. In 1988, Exo-ICE, a successful proposal to the Space Station Attached Payload AO made use of one level of the passive intact capture technology that was laboratory-proven at the time of the proposal submission. In this plan, supportive activities toward the overall development of this technology shall be pursued with an emphasis toward the documentation of achievements thus far.

W93-70251 199-52-82
Ames Research Center, Moffett Field, CA.
EXPLORATION EXOBIOLGY
D. L. DeVincenzi 415-604-5251

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 the following: programatically-oriented activities to define exobiology science objectives and payloads for SEI missions; research activities to characterize the physical and chemical environment of Mars; development of Earth models for extant and extinct life on Mars and Mars analog environments; and study of applicability of telepresence concepts to exobiological exploration of planetary bodies. In addition, ground-based and mission data will be analyzed in order to identify Mars landing sites optimized for exobiology objectives.

W93-70252 199-55-19
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED PROGRAMS THEORETICAL BIOLOGY
John E. Dorband 301-286-9419

We are pursuing a new and unique approach to understanding the behavior of natural environmental systems - creating algorithms to simulate evolutionary dynamical systems as cellular dynamata on massively parallel processor arrays. The origin of life is perhaps the most challenging natural phenomenon to approach in this manner. To explain the origin of life we must explain the highly improbable accumulation of 'biological information' into primitive systems which have the characteristics of living organisms: bounded open dissipative (metabolic) systems which self-replicate with diversity. The hot spring model proposes that a sequence of environments within Archaean submarine hot spring systems provided the constraints in which the prebiotic synthesis, self-organization, and early evolution of living systems occurred. We propose to create models of self-organization in the following: (1) a collection of autocatalytically interacting molecules within a primitive cell in a hot spring fracture; (2) a collection of such replicating cells within a fracture through which fluid flows (an Eigen 'evolution' reactor); and (3) a collection of cells in an emerging laminated microbial community at the interface between the hot spring environment and the sea floor. We have created a UNIX-based C program with which such simulations can be readily studied on the MasPar, producing 3D video visualizations.

W93-70253 199-61-11
Lyndon B. Johnson Space Center, Houston, TX.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELS) PROJECT
D. L. Henninger 713-483-5034

Missions scenarios envisioned for the Space Exploration Initiative are very long-duration missions and will last months to years at a time. Human life support systems must minimize resupply from Earth and enhance the self-sufficiency of crews at remote locations on the Moon and Mars. These life support systems will make use of higher plants, microorganisms, and physicochemical processes for the production of water, food, and oxygen while converting carbon dioxide and recovering resources from waste materials. Development of a Controlled Ecological Life Support System (CELS) will be a pivotal capability for missions to explore the solar system. Research within the CELSS Program began several years ago and is now able to capitalize on much of that research by moving into the area of technology development. The CELSS Breadboard Project was designed to examine and verify plant production under tightly controlled conditions at a sufficiently large scale. Development of test bed facilities must be continued for integration of all life support components and subsystems, both biological and physicochemical. Efforts must continue to design a human-rated life support systems test facility. This RTOP is to continue life support research and development and to continue development of test bed facilities.

W93-70254 199-61-12
Ames Research Center, Moffett Field, CA.
BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELS) SUPPORT SYSTEMS
R. D. MacElroy 415-604-5573

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 (CELS) Projects and the design of experiments to be conducted in space.

Solar Terrestrial Mission Operations and Data Analysis
W93-70255 370-03-00
Goddard Space Flight Center, Greenbelt, MD.
Archival Task for the Equatorial San Marco D, AE and DE Satellite Missions
R. A. Hoffman 301-286-7386

The objective is to archive on well documented media the processed experimental data from the San Marco D and AE satellites and the telemetry data from Dynamics Explorer 1 (DE 1) satellite. The bulk of this RTOP will be devoted to processing data from the San Marco EFI, IVI and WATI experiments to an agreed-upon common data rate and then merging these files, together with data supplied by the European San Marco experimenters, onto a set of National Space Science Data Center (NSSDC) approved media. The merging will be done at the University of Texas at Dallas via a Goddard Space Flight Center (GSFC) grant from these funds. Secondary tasks will be the clean-up of the final files of the AE data bases and the completion of the optical disk copying of telemetry data for DE 1.

Astrophysics Mission Operations and Data Analysis

W93-70256 399-18-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIPPARCOS VLBI
R. A. Preston 818-354-6895

The ESA satellite HIPPARCOS will determine the positions, proper motions and trigonometric parallaxes of 100,000 optical stars with unprecedented accuracy. We plan to tie the HIPPARCOS observations to the JPL Very Long Baseline Interferometry (VLBI) celestial reference frame, which is composed of the radio cores of distant quasars and galaxies. This will allow HIPPARCOS studies of stellar and galactic dynamics to be 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, we have continued an astrometric VLBI observational program on 12 radio stars, mostly of the RScvN class of close binaries (approximately 0.001 second separation), using phase-referencing techniques. Our observations have also provided significant new information on stellar radio emission mechanisms.

W93-70257 399-20-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ENERGETICS OF INTERSTELLAR CLOUDS
W. D. Langer 818-354-5823

The purpose of this program is to study the energy balance in interstellar clouds. The structure and evolution of interstellar clouds and the star formation mechanism within them are strongly influenced by the energy balance and chemical processes characterizing the cloud. We will obtain Cosmic Background Explorer (COBE), Infrared Astronomy Satellite (IRAS), HI and CO (isotopic) surveys of nearby interstellar clouds, and use these, along with theoretical models, to determine the gas and grain properties, influence of grains on the energy and chemistry, and energy and chemical balance. Among the most important information needed for understanding these processes is identification of heating and cooling sources, radiation field, and chemical and dust composition. We will study clouds with a wide range of radiation fields and include core-halo and clumped structures. We will expand and develop numerical models for the chemistry and structure using stratified isotopic chemistry models, including radiation extinction and dust emission, and radiative transfer for gas emission. We will also develop analogous codes for clouds with clumpy structures.

W93-70258 399-20-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IPAC ASTROPHYSICS DATA SYSTEM (ADS) SUPPORT
J. C. Good 818-584-2939

Infrared Processing and Analysis Center's (IPAC's) support of the Astrophysics Data System (ADS) Project involves System Engineering, operation of the ADS system, and technical support of the ADS service nodes. IPAC is the Operations Center for ADS. As such it provides logistical and consulting support for the Project as a whole and individually for each of the ADS service nodes. IPAC is responsible for the health and welfare of the operational system, and the ADS Operations Manager at IPAC has authority over operational decisions that affect the system. The Systems Engineering of the ADS is controlled through IPAC. The ADS System Scientist at IPAC has authority over all technical aspects of project development.

W93-70259 399-20-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA/IPAC EXTRAGALACTIC DATABASE
G. Helou 818-584-2928

The purpose of the NASA/IPAC (Infrared Processing and Analysis Center) Extragalactic Database (NED) is to provide an on-line database service for supporting extragalactic research. The database will contain up-to-date references to the literature, abstracts from the major journals, and a master directory of objects, their names and cross-identifications. Astronomical data on these objects will be collected from the literature and entered into the database. A convenient, user-friendly interface is a requirement for efficient use of the database. The database and interface are set up and maintained on the IPAC computers, and are made available by remote access over electronic computer networks to the astronomical community at no cost to the user. These services are also accessible world-wide.

W93-70260 399-20-01
Ames Research Center, Moffett Field, CA.
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-604-4164

The objectives of this RTOP are to, first, undertake a unified theoretical analysis of the problem of star formation and, second, to theoretically study the evolution of dust in the interstellar medium. 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; the origin of water masers and Herbig-Haro objects associated with star-forming regions; the influence of strong shock waves on the abundance, composition and the distribution of interstellar dust; the role of circumstellar polycyclic aromatic hydrocarbons (PAH's) in the formation of C-stardust; and the formation of interstellar icy grain mantles.

W93-70261 399-50-00
Ames Research Center, Moffett Field, CA.
THE NATURE OF INTERSTELLAR DUST, ICES AND POLYCYCLIC AROMATIC HYDROCARBONS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to analyze spectroscopic data taken from spacecraft in the vacuum ultraviolet and infrared spectral regions to study the chemical composition and physical state of interstellar dust, ices, and polycyclic aromatic hydrocarbons (PAH's). The approach of this RTOP is to use laboratory-produced data to direct the observing strategy used on satellites with...
spectroscopic capabilities in the vacuum ultraviolet and infrared spectral regions. The laboratory data we have on PAH’s, interstellar dust, and ices show very specific signatures of these materials in spectral regions never measured. These regions will be studied with soon-to-be-launched spacecraft. This laboratory data, and other experiments we can perform as needed, will be used to interpret the observations from these spacecraft. This analysis affords the potential of (1) discovering new and important interstellar molecules; (2) determining the deuterium distribution in interstellar ices and PAH’s; and (3) uniquely identifying some specific interstellar PAH’s based on their far-IR spectra.

**EOS Data Information System**

**W93-70262**
Goddard Space Flight Center, Greenbelt, MD.
**A 4D DATA ASSIMILATION FOR EOS COMPUTER SUPPORT**
Richard B. Rood
301-286-8203

The objective of this RTOP is to provide computer resources for Earth Observing System (EOS) related data assimilation. This RTOP provides money for two items: (1) a Central Computer Facility, which provides super computer access for data assimilation; and (2) a Local Network, where workstations and ancillary equipment are provided for assimilation activities. Support is also required for personnel to maintain the network.

**W93-70263**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**ROLE OF AIR-SEA EXCHANGES AND OCEAN CIRCULATION (COMPUTING)**
W. T. Lu
818-354-2394
(429-81-10)

This is an interdisciplinary science investigation of NASA’s Earth Observing System (EOS) program. The objective is to study the role of ocean circulation and the ocean-atmosphere exchanges in affecting global climate changes. Methods to compute ocean surface heat, momentum, and water fluxes using satellite data are being developed and improved. The responses of the atmosphere and ocean to these surface forcings, as related to the storage and transport of heat and greenhouse gases, will be examined. Tropical ocean-atmosphere interaction will be studied first. The energy and hydrologic balances of the coupled ocean-atmosphere system will be examined. An eddy-resolving general circulation model to assimilate satellite data and to provide a realistic four-dimensional description of ocean circulation will be developed. We will extend and join our funded studies in satellite missions such as Environmental Research Satellite (ERS)-1, NASA Scatterometer (NSCAT), Topex/Poseidon, and Tropical Rainfall Measuring Mission (TRMM). We will utilize our established participation and leadership in the field campaigns, the monitoring programs, and the modeling efforts of Tropical Ocean and Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE). We will draw upon operational satellite data and will follow closely the development of data systems such as International Cloud Climatology Project (ISCCP), Welnet, Global Precipitation Climatology Project (GPCP) and Surface Radiation Budget (SRB) project. We will contribute to the Global Energy and Water Cycle Experiment (GEWEX) as soon as it is ready to address problems over the ocean. These studies will pave the way for the era of EOS platforms.

**W93-70264**
Goddard Space Flight Center, Greenbelt, MD.
**GLOBAL HYDROLOGIC CYCLE**
William K.-M. Lau
301-286-7208
(429-81-16)

The objective of this RTOP is to improve our understanding of the physical mechanisms of atmospheric hydrologic processes; the role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales; and the role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. The approach is to make extensive use of data collected from existing satellite missions and from Earth Observing System (EOS); to use results obtained for the pre-EOS phase to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis, and to emphasize a synergistic approach based on analysis of data from space and non-space platforms as well as modeling.

**W93-70265**
Goddard Space Flight Center, Greenbelt, MD.
**BIOSPHERE ATMOSPHERIC INTERACTIONS**
Piers J. Sellers
301-286-4173

A global atmosphere general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO2. Regional ecology models will be developed.

**W93-70266**
Goddard Space Flight Center, Greenbelt, MD.
**EOS IDS, EOSDIS MONEY**
Mark R. Schoeberl
301-286-5819

The investigation is a two-component effort to characterize both the short- and long-term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with the Upper Atmosphere Research Satellite (UARS) and on through the EOS observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N2O, CH4, NO2, NO etc.). These data sets will be made available to the EOSDIS (EOS Data and Information System) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, we are interested in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. We propose to use the data assimilation model and other 2- and 3-D models to facilitate the generation of the climatological data sets mentioned above, as well as undertake theoretical investigations. This RTOP area concerns the upgrade of computer facilities to accomplish this investigation.

**W93-70267**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
**PROJECT TO INTERFACE MODELING: EOSDIS ACTIVITIES**
R. W. Zurek
818-354-3725
(429-81-72)

The unique observational capabilities provided by the Earth Observing System (EOS) program have the potential for driving major improvements in climate models at the global and regional scale. The National Center for Atmospheric Research (NCAR) EOS Project to Interface Climate Modeling on Global and Regional Scales with EOS Observations is a selected interdisciplinary investigation designed to work synergistically between the selected EOS measurement capabilities, detailed research on the physical mechanisms of climate change, and the development of global climate and global change models. The emphasis is on surface and atmospheric processes related to the hydrological cycle and to atmospheric circulation and radiation. In parallel with the National Center for Atmospheric Research’s climate modeling program, the project will focus on the sensitivity of climate models to EOS observations, the framework for the assimilation of EOS data needed for climate models, the application of EOS data sets to...
model validation and as model boundary conditions, and development of climate model parameterizations and diagnostics that are more compatible with remotely sensed (satellite) data than those at present. The project will also carry out prototype applications of currently available data sets to improve our framework for relating EOS data to climate models. New approaches will be developed and applied to the analysis of satellite data, as applicable to the EOS sensors and for testing model simulations. New and modified approaches to the archiving and the visualization of global satellite data and model simulations will also be developed as needed. Activities include (1) documentation and provision of prototype data sets and of model-generated fields as required; and (2) implementation, documentation, and support of interactive software tools for the analysis and display of satellite remote sensing data and for the comparison of such data with climate model simulations.

W93-70268 428-81-80
Goddard Space Flight Center, Greenbelt, MD.
EOS DIS FOR IDS ON BIOGEOCHEMICAL FLUXES AT AIR/SEA INTERFACE
Anne M. Thompson  301-266-2629

The objective of this RTOP is to outline a system for satellite data input, model analysis and output to be delivered to EOS DIS (Data and Information System). Pre-launch of these satellites will use existing data sets (e.g., Coastal Zone Color Scanner, CZCS) and post-launch data from MODIS (Moderate Resolution Imaging Spectrometer), STIJKSAT, AMSU (Advanced Microwave Sounding Unit), MOPPITT/TRACER, and other instruments. Data processing for the task is likely to involve transfer and storage gas distributions. The GCM (General Circulation Model) will be made up of a grid appropriate for GCM calculations. This RTOP deals with the computational requirements of this investigation. It will include updating of hardware and software to accomplish on a large grid (N computations) what we have been doing in a single computer mode on a VAX 11/780. Hardware choices will be made to ensure compatibility and efficient data transfer among EOS teams, members, both at GSFC and WHOI (Woods Hole Oceanographic institute).

W93-70269 428-81-94
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
D. C. Pieri  818-354-6299

Funding is requested under this RTOP for computing support for the Earth Observing Systems (EOS) Volcanology interdisciplinary Science Team activities at the Jet Propulsion Laboratory (JPL). Computing support under this RTOP will be directed toward algorithm development for the following activities: (1) remote detection of volcanic eruptions by thermal anomaly recognition; (2) remote determination of surface temperature distributions of active lava flows; and (3) determination of long-term thermal energy budgets for active volcanoes. Progress has been made on a related RTOP in preliminary development of multiple band deconvolution algorithms for modeling radiant energy and temperature distributions for sub-pixel heat sources, although no funding was requested under this RTOP in FY-91 and FY-92. Data used for this effort included aircraft (NS001) and orbital analog data (AVHRR). Support this year (FY-93) will be required for procurement of a Co-l workstation and support for the procurement of a central server machine for the JPL part of IDS Volcanology Team (FY-95 and FY-96).

W93-70270 428-81-96
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
J. A. Crisp  818-354-9036

One objective is to develop an algorithm for an eruption alarm based on the detection of an SO2 anomaly by the Moderate-Resolution Imaging Spectrometer (MODIS). Algorithms will also be developed for estimating SO2 concentrations in volcanic plumes, using data from MODIS and Atmospheric Infrared Sounder (AIRS). Another objective is to provide input to the TES and MLS teams for volcanology study requirements (maps of SO2, HCl, and HF concentration) and to prepare for the analysis of the data that will be provided by these teams by studying pre-EOS analog datasets. The ultimate objectives for the EOS execution phase will be to produce global maps showing the distribution and timing of SO2 plumes and the size of SO2 anomalies. Assessments will be made of the annual contribution of volcanoes to the SO2 budget of SO2 and the related climate effect. The SO2 data will also be used to study the relationship between magmatic activity and fluctuations in SO2 emissions and the ratio SO2/HCl, which are useful in the study of volcanic hazards and magma chamber conditions. SO2 estimates from MODIS and AIRS data will be compared with aerosol maps produced by other EOS instruments to study the conversion from SO2 into sulfate aerosols. The SO2 alarm and measurement algorithms will be developed and tested by running radiative transfer simulations and by studying pre-EOS analog datasets. Continued communication with the TES and MLS teams will be maintained to ensure that we are prepared for analysis of the SO2 and HCl data that these teams will provide.

W93-70271 428-81-99
Goddard Space Flight Center, Greenbelt, MD.
STUDIES OF VOLCANIC SO2
Ariin J. Krueger  301-286-6358

The objective of this RTOP is to develop an Earth Observing Satellite (EOS) data base of volcanic eruptions derived from TOMS (Total Ozone Mapping Spectrometer) sulfur dioxide analyses. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, Advanced Earth Observing System (ADEOS), and NOAA satellites and Advanced Very High Resolution Radiometer (AVHRR) and thermal IR sounders on NOAA satellites. The product will be daily files and maps containing the current and spatial distribution of the sulfur dioxide in eruption clouds. This information is potentially useful in volcano-climate studies, volcanology, as material tracers in meteorological studies, and in development of volcanic hazard abatement techniques.

W93-70272 428-82-06
Goddard Space Flight Center, Greenbelt, MD.
OCEAN COLOR DATA SYSTEM
Robert G. Kirk  301-286-7895

This RTOP covers the part of the NASA in-house program associated with the POP for the Sea-viewing Wide-Field Sensor (SeaWIFS) spacecraft. This RTOP covers the following topics: management costs; data receipt, processing, and distribution; and algorithm and validation programs.

W93-70273 428-82-11
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTOMATED GEOPHYSICAL PROCESSOR DEVELOPMENT FOR THE ALASKA SAR FACILITY
R. Kwok  818-354-5614

The long-term objective is to develop a geophysical processor system for ice and ocean studies that is capable of automated data processing producing a classification of ice types and an extraction of ice motion parameters from multi-date Synthetic Aperture Radar (SAR) imagery. The goal is to provide data products that can be directly utilized for the analysis of large-scale ice dynamics in the polar regions as well as for practical applications such as navigation and deployment of drilling platforms. As a means to this goal, new data extraction and image processing techniques will be developed under this RTOP and integrated into an operational system for ice information extraction from SAR imagery. This system will be evaluated using Specialized Experimental Applications Satellite (SEASAT) imagery, with the eventual application of the operational system to process ERS-1 (Earth Resources Satellite) data acquired at the Alaska SAR Facility.
The Earth's atmosphere, ocean, and land surface. This system is
4D DATA ASSIMILATION FOR EOS
low radiance applications of AVHRR data.
Radiance targets (oceans) to calibrate ocean-specific sensors and
diverse targets (forests) to investigate spectral shifts, and low
the target for calibration transfer. Future targets will include brighter
a NASA ER2. White Sands, NM, has been used in the past as
calibrated at GSFC before and after a flight. All flights will be on
required
reference to standard lamps and/or standard detectors to maintain
Standards and Technology (NIST) traceable aperture radiometric
Spectrometer (MODIS) and other Earth Observing System (EOS)
AVHRR Pathfinder Project; and improve the method, equipment
results to interested user groups, and in particular to the
Advanced Very High Resolution Spectrometer (AVHRR), Visible
Infrared Spin Scan Radiometer (VISSR)/Atmospheric Sounder (VAS), and GOES Imager at least three times a year; provide
flying aircraft as a radiometric calibration transfer standard; calibrate
wavelengths, using a calibrated spectroradiometer on board a high
satellite radiometers observing the Earth
Peter Abel 301-286-8829
The objectives are to determine the radiometric gains of satellite radiometers observing the Earth at visible and near-infrared
wavelengths, using a calibrated spectroradiometer on board a high flying aircraft as a radiometric calibration transfer standard; calibrate
Advanced Very High Resolution Spectrometer (AVHRR), Visible
Infrared Spin Scan Radiometer (VISSR)/Atmospheric Sounder (VAS), and GOES Imager at least three times a year; provide
results to interested user groups, and in particular to the
International Satellite Cloud Climatology Project (ISCCP) and the
AVHRR Pathfinder Project; and improve the method, equipment
and software to establish a rapid response and data analysis
capability to underly the Moderate-Resolution Imaging Spectrometer (MODIS) and other Earth Observing System (EOS)
radiometers. The approach is based on the National Institute of Standards and Technology (NIST) traceable aperture radiometric
standards maintained at the Goddard Space Flight Center (GSFC).
These standards must be recalibrated on a monthly basis with
reference to standard lamps and/or standard detectors to maintain
required absolute accuracy. The aircraft spectroradiometer is
calibrated at GSFC before and after a flight. All flights will be on
a NASA ER2. White Sands, NM, has been used in the past as
the target for calibration transfer. Future targets will include brighter
targets (clouds) to calibrate larger dynamic ranges, spectrally
diverse targets (forests) to investigate spectral shifts, and low
radiance targets (oceans) to calibrate ocean-specific sensors and
low radiance applications of AVHRR data.

EOS Science

Peter Abel 301-286-8829

The objectives are to determine the radiometric gains of satellite radiometers observing the Earth at visible and near-infrared
wavelengths, using a calibrated spectroradiometer on board a high flying aircraft as a radiometric calibration transfer standard; calibrate
Advanced Very High Resolution Spectrometer (AVHRR), Visible
Infrared Spin Scan Radiometer (VISSR)/Atmospheric Sounder (VAS), and GOES Imager at least three times a year; provide
results to interested user groups, and in particular to the
International Satellite Cloud Climatology Project (ISCCP) and the
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and software to establish a rapid response and data analysis
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diverse targets (forests) to investigate spectral shifts, and low
radiance targets (oceans) to calibrate ocean-specific sensors and
low radiance applications of AVHRR data.
missions and from EOS, to use results obtained for the pre-EOS phase to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis; and to emphasize a synergistic approach based on analysis of data from space and non-space platforms as well as modeling.

**W93-70279**
Goddard Space Flight Center, Greenbelt, MD.

**BIOSPHERE ATMOSPHERIC INTERACTIONS**
Piers J. Sellers 301-286-4173

A global atmospheric general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO2. Regional ecology models will be developed.

**W93-70280**
Goddard Space Flight Center, Greenbelt, MD.

**EOS IDS, STRATOSPHERIC TEMPERATURE AND TRACE GAS TRENDS**
Mark R. Schoeberl 301-286-5819

The investigation is a two-component effort to characterize both the short- and long-term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with Upper Atmosphere Research Satellite (UARS) and on through the Earth Observing System (EOS) observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N2O, CH4, NO2, NO, etc.). These data sets will be made available to the Earth Observing System Data Information System (EOSDIS) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, we are interested in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. We propose to use the data assimilation model and other 2- and 3-D models to facilitate the generation of the climatological data sets mentioned above as well as undertake the theoretical investigations.

**W93-70281**
Langley Research Center, Hampton, VA.

**EOS SCIENCE**
W. R. Hook 804-864-6056

The objective of this RTOP is to improve understanding of atmospheric processes which influence global change and thereby contribute to the interdisciplinary Earth Science investigations being carried out as a part of the Earth Observing System (EOS) Program. Specific tasks include: (1) studies of the role of clouds in the Earth's radiant energy budget; and (2) observational and modeling studies of radiative, chemical, and dynamical interactions in the Earth's atmosphere.

**W93-70282**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**POLAR EXCHANGE AT THE SEA SURFACE: JPL COMPONENT**
F. D. Carsey 818-354-8163

This RTOP covers the JPL work as part of the POLES Earth Observing System (EOS) Interdisciplinary Project. Our work research will concentrate on the generation of algorithms for sea ice geophysical fluxes from satellite data with a focus on scientifically significant ice-margin regions, at present the Weddell and Greenland Seas. The objective of this work is the accurate, routine estimation of heat, brine and momentum fluxes from these polar seas. The basic approach is the merging of data from Special Sensor Microwave Imager (SSM/I) and Synthesis Aperture Radar (SAR) and other data available. Specifically we plan in 1993 to: (1) continue studies using SAR and SSM/I data in studies of algorithms to generate the surface heat and brine fluxes of the Greenland Sea; (2) begin this process for the Weddell Sea; and (3) examine the consequences of errors and general data characteristics of the SAR ice motion and SSM/I data streams. It will be necessary to initiate geophysical flux estimation production through the latter part of the decade, including particularly the flight phase of RADARSAT and EOS. Our approach is to use SAR data to track the ice and estimate opening and closing while using SSM/I data and weather analyses to estimate thickness changes with time. A key element of the flux analysis is the use of ice motion data in the conversion of SSM/I Tb's to ice thickness changes. We have modeled the expected changes in Tb in both the East Greenland Current and the Odden region, and next we will check the sensitivity of this calculation to errors and gaps in the ice motion field as generated on the SAR schedule of 1 to 2 velocity determinations per week. The ice-motion gaps arise in two ways; some ice is simply missed by the limited sampling procedure of the narrow-swath SAR (or the cloud-limited Advanced Very High Resolution Radiometer (AVHRR)), and some ice motion data are missed if the changes in the ice cover between SAR observations are great enough. At present the specific robustness of the ice motion analysis to ice cover changes has not been assessed. Finally the accuracy of ice motion to predict actual opening and closing has not been tested. This testing will be part of the Global Positioning System (GPS) validation performed under the Alaska SAR Facility-NASA Radar Altimeter (ASF-NRA). There is a critical need for analyses of the sort discussed here. For the 1988 data analysis we used ice motion data from AVHRR generated by the Danish scientists in the Greenland Sea Project; we plan to use Earth Resources Satellite (ERS-1) SAR-derived data for the winters of 1992 and 1994, and possibly 1993.

**W93-70283**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**PROJECT TO INTERFACE MODELING**
R. W. Zurek 818-354-3725

(429-81-72)

The unique observational capabilities provided by the Earth Observing System (EOS) program have the potential for driving major improvements in climate models at the global and regional scales. The National Center for Atmospheric Research (NCAR) EOS Project to Interface Climate Modeling on Global and Regional Scales with EOS Observations is a selected interdisciplinary investigation designed to work synergistically between the selected EOS measurement capabilities, detailed research on the physical mechanisms of climate change, and the development of global climate and global change models. The emphasis is on surface and atmospheric processes related to the hydrological cycle and atmospheric transport. In parallel with the NCAR climate modeling program, the project will focus on the sensitivity of climate models to EOS observations, the framework for the assimilation of EOS data needed for climate models, the application of EOS data sets to model validation and as model boundary conditions, and development of climate model parameterizations and diagnostics that are more compatible with remotely sensed (satellite) data than those at present. The project will also carry out prototype applications of currently available data sets to improve our framework for relating EOS data to climate models. New approaches to the analysis of satellite data will be developed, as applicable to the EOS sensors and to the validation of model simulations. This includes new and modified approaches to archiving and visualization of global satellite data and model simulations, as needed. Specific JPL research tasks include: (1) provision, analysis, and documentation of prototype data sets; (2) determination of the sensitivity of EOS observing systems to model-required or model-generated fields; (3) development, refinement and application of interactive software tools for the analysis and display of satellite remote sensing data and for the comparison of such data with climate model simulations.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
W93-70284
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SCIENCE FOR WHOI/GSFC EOS PROJECT:
D. C. Pieri 818-354-6299
(428-81-94)

Support is requested in this RTOP for science activities to be carried out under sponsorship of the Earth Observing System (Eos) Volcanology Interdisciplinary Science Team. Science activities here are related to science algorithm development as outlined in the revised Volcanology IDS Proposal entitled, 'A Global Assessment of Active Volcanism, Volcanic Hazards, and Volcanic Inputs to the Atmosphere from the Earth Observing System'. Work under this RTOP is directed toward the remote sensing of the thermal properties of active volcanoes during eruptions as well as during quiescent baseline periods. Specific activities in the thermal area to be carried out under this RTOP are: (1) remote detection of volcanic eruptions by thermal anomaly recognition; (2) remote determination of surface temperature distributions of active lava flows; and (3) determination of long term thermal energy budgets for active volcanoes. During the operational phase of Eos, these observations will be carried out using the near-, mid-, and thermal-IR bands of Moderate Resolution Imaging Spectrometer (MODIS-N) and Advanced Very High Resolution Radiometer (ASTER) instruments. Part of the algorithm development for (1) will involve the creation of an alarm system that will scan incoming MODIS-N data daily to alert team members of anomalously high thermal spikings over volcanic areas. The monitoring of actively erupting volcanoes, especially applicable in the study of active volcanism, where conventional monitoring using optical sensors or in situ measurements are either impossible due to atmospheric obstruction or too dangerous for manned exploration. However, such monitoring is necessary both for hazard assessment of active eruptions and for understanding the past history and long-term effects of the eruptions on local, and in extreme cases, global climate.

GLOBAL SCIENCE FOR WHOI/GSFC EOS PROJECT:
H. A. Zebker 818-354-8780
(428-81-95)

This RTOP, in conjunction with the related RTOP 428-81-95, is part of the Earth Observing System (Eos) Interdisciplinary Science proposal, 'Global Assessment of Active Volcanism', headed by Dr. Peter Mouginis-Mark of the University of Hawaii. Our role in this overall study is to develop the means to map active volcanoes topographically using interferometric Synthetic Aperture Radar (SAR) data acquired by the Eos SAR, ESA Remote Sensing Satellite-1 (ERS-1), RADARSAT, and any other available orbital SARs. The orbital SAR's will provide data from which we may derive topographic maps of 10 m height accuracy over images tens of kilometers in extent at a spatial resolution of 20 to 30 m. It may also be possible to generate topographic change maps, on a relative rather than absolute scale, sensitive to cm scale changes in height that may serve as precursors to eruptive events. Topographic measurements before and after volcanic events will permit estimation of displaced volumes of material following explosive activity, which are extremely important in the estimation of the atmospheric effects of Alaskan eruptions and their influence on climate. Local climate conditions are also affected by the interaction of lava flows on frozen ground and ice sheets. While not explicitly part of this investigation, an understanding of the latter effect would be of major importance in hazard assessment in regions such as Iceland where melting of ice during an eruption is significant. These measurements derived from radar data are especially applicable in the study of active volcanism, where conventional monitoring using optical sensors or in situ measurements are either impossible due to atmospheric obstruction at optical wavelengths or too dangerous for manned exploration. However, such monitoring is necessary both for hazard assessment of active eruptions and for understanding the past history and long-term effects of the eruptions on local, and in extreme cases, global climate.
development will continue. Those algorithms for which I have the prime responsibility include No. 18-Low Temperature Volcanic Thermal Anomalies, and No. 21-Atmospheric Profiles. Others, to which I will also contribute, include No. 1-Eruption Detection by Thermal Spike, No. 4-Eruption Plume Temperature, No. 15-Temporal Change in Volcano Morphology, No. 16-Lava Flow Temperature Distribution, and No. 23-Supplemental Data Sets. The algorithm development work is partially supported under RTOP 465-44-02 (Evolution of Volcanic Terrains).

W93-70298
Goddard Space Flight Center, Greenbelt, MD.

STUDIES OF VOLCANIC SO2, THEORY
Arlin J. Krueger 301-286-6358

The objective of this RTOP is to develop algorithms for retrieval of sulfur dioxide column amounts from UV radiiances measured with Total Ozone Mapping Spectrometer (TOMS) instruments, and for assessment of associated parameters, such as plume height and velocity. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, Advanced Earth Observing System (ADEOS) and NOAA satellites, and Advanced Very High Resolution Radiometer (AVHRR) and thermal IR sounders on NOAA satellites. This information is potentially useful in volcano-climate studies, volcanology, and as material tracers in meteorological studies.

W93-70299
Goddard Space Flight Center, Greenbelt, MD.

FOREIGN VISITOR SUPPORT
Compton J. Tucker 301-286-7122
(462-41-82)

The objective is cooperative Brazilian-U.S. satellite remote sensing research on the Amazon Basin of Brazil. This RTOP will support a Brazilian scientist at NASA/Goddard for this cooperation. Landsat Thematic Mapper (TM) and NOAA Advanced Very High Resolution Radiometer (AVHRR) data will be cooperatively analyzed to study tropical forests, tropical savannas, investigate techniques for assessing tropical deforestation, identify and monitor tropical forest and savanna fires, and relate these topics to the carbon cycle within the Amazon Basin of South America.

Space Physics Theory

W93-70291
Goddard Space Flight Center, Greenbelt, MD.

SPACE PHYSICS THEORY PROGRAM
T. J. Birmingham 301-286-7110

The subject RTOP supports a program of theoretical analysis and computer modeling carried out by 17 autonomous groups in the university, industrial, and government communities to whom funds are distributed via grants, contracts, and transfers. The Space Physics Theory Program (SPTP) has been in continuous existence since FY-79, but it has only been managed as a GSFC project since FY-91. Fund recipients are selected by the NASA NRA, with each group participating for one year. The program is designed to be a balanced GSFC/Lab for theoretical physics. The 17 autonomous groups are distributed among the space science centers at GSFC and among universities, industrial institutions, and national laboratories. The Space Physics Theory Program has been in continuous operation for over 12 years, and is expected to continue. A majority of the programs are sponsored by NASA GSFC, with the remainder sponsored by NASA's Office of Aeronautics and Space Technology (OAST) and NASA's Office of Earth Sciences (OES) for the Space Physics SR&T Program.

Space Physics SR&T

W93-70292
Goddard Space Flight Center, Greenbelt, MD.

SOLAR WIND-MAGNETOSPHERE-IONOSPHERE COUPLING, MAGNETIC FIELD MODELING, AND MAGNETOTAL DYNAMICS
James A. Slavin 301-286-5839

This research effort consists of seven distinct tasks directed at advancing our knowledge and understanding of the global solar wind-magnetosphere-ionosphere coupled system. Task 1 (P.I.- A. Klimas) investigates solar wind-magnetosphere coupling through the use of recently developed predictive filtering and nonlinear chaos modeling techniques. Task 2 (P.I.- J. Slavin) examines the structure and dynamics of the earth's magnetosphere through a balanced mixture of theoretical and data analysis modeling studies. Task 3 (P.I.- M. Smith) investigates the processes by which solar wind plasma enters the magnetosphere and penetrates to low altitude. Task 4 (P.I.- D. Stern) consists of theoretical modeling studies directed toward the investigation and representation of the major magnetospheric current systems and the magnetic fields they generate. Taken together, these investigations offer a well balanced GSFC/Lab for Extraterrestrial Physics (LEP) Research Program addressing most key aspects of solar wind-magnetosphere-ionosphere coupling.

W93-70293
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MAGNETOSPHERIC COUPLING
R. Goldstein 818-354-2024

This RTOP consists of two subtasks: (1) Cometary Plasma Physics using Data from the Giotto Ion Mass Spectrometer which includes analysis of Giotto/Halley comet plasma data for wave processes and energy transport; and (2) Jovian Magnetospheric Processes which include analysis of time variability of Jovian decimetric (sychrotron) radiation with ground-based radio telescope observations, and comparison of results with theoretical models.

W93-70294
Goddard Space Flight Center, Greenbelt, MD.

THERMOSPHERE-IONOSPHERE-MESOSPHERE-MAGNETOSPHERE INTERACTIONS
R. E. Hartle 301-286-6234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, and 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, polar cap absorption (PCA) events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamical processes, equatorial 'bubble' formation, stable auroral red (SAR) Arcs, etc.
Space Physics ATD

**W93-70295**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**INTERDISCIPLINARY ATD STUDIES**
C. L. Yen 818-354-4899

The objective of this RTOP is to generate innovative approaches to conduct space physics missions. The study leader shall coordinate with the space physics science community, Code-SS advanced studies office, and JPL management to set priorities on a set of studies potentially beneficial to Code-SS. Potential categories of studies are: (1) applications of simplified mission design and lightweight spacecraft concepts to achieve low cost, and applications of advanced or new technologies on problematic elements of various missions.

**W93-70296**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SOLAR PROBE ATD**
J. E. Randolph 818-354-2732

The objectives of this RTOP are to develop required material properties for high temperature shield material candidate, to support spacecraft system development using Lite-Sat technology, and develop cost estimates for both the spacecraft and thermal shield. This will be accomplished by conducting high temperature carbon-carbon material testing utilizing as a baseline the JPL developed heat shield configuration. The tests required are: (1) directional, spectral emittance and normal, total emittance at temperature levels of 1000 to 2400 K for carbon-carbon sheets in both as manufactured and roughened conditions; and (2) thermal conductivity of carbon-carbon sheets and the sandwich structure (for the IR shield), at temperatures between 1400 and 2400 K. FY-93 test data will be analyzed and a written report of the test data and analytical effort will be provided. System spacecraft studies will be conducted with industry support (RFI) to address development concepts that will be supported by the Lite-Sat technology. Using this technology initial cost estimates for the spacecraft development and fabrication will be developed. Support from industry (RFI) will be requested to develop concepts and initial cost estimates for the shield system. This shield concept will be compatible with the Lite-Sat class of spacecraft. The approach is to develop high-temperature material test data by utilizing industry capability, and request industry to develop cost data for the Solar Probe by using Lite-Sat technology and shield concepts. We will (1) contact industry to develop high-temperature material data for shield material; (2) conduct a study to develop spacecraft configuration and initial cost estimates utilizing Lite-Sat technology; and (3) conduct a study to develop shield configuration and initial cost estimate.

**W93-70297**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**SPACE PHYSICS PROGRAM SUPPORT/DETAILLEES**
R. Goldstein 818-354-0241

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

Space Physics Sounding Rocket Research

**W93-70298**
Goddard Space Flight Center, Greenbelt, MD.

**SOUNDRING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS**
R. F. Pfaff 301-286-6328

The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, electric fields and electromagnetic waves in the atmosphere, ionosphere, and near-Earth magnetosphere. Emphasis is placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Sounding rockets provide the only access for in-situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Historically, this approach has logically been extended to include sounding rocket experiments at remote sites of keen geophysical importance (e.g., the dip equator or the auroral zone); experiments involving sounding rocket flights in association with simultaneous satellite measurements; flight testing of new instrumentation and measurement techniques; and investigations of the electrodynamics of middle atmosphere (i.e., below 90 km), including experiments that deploy special payloads such as those that 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.

Spacelab Payload Instrument Development/ Astrophysics

**W93-70299**
Goddard Space Flight Center, Greenbelt, MD.

**HIGH ENERGY ASTROPHYSICS INTERNATIONAL PROGRAMS**
J. F. Ormes 301-286-8801

This RTOP provides scientific support and instruments within the Laboratory for High Energy Astrophysics for missions on foreign spacecrafts and other foreign collaborative efforts. As of April 1992, these projects include the Monitoring X-ray Telescope (MOXE) for the Russian Spectrum Roentgen Gamma satellite, ESA's X-ray Multi Mission (XMM), and the Konus instrument being supplied by the USSR for the International Solar Terrestrial Physics (ISTP) Wind spacecraft. MOXE is an all sky monitoring x-ray telescope which is sensitive to transients on a variety of time scales. This instrument will identify interesting sources for the other instruments on board the satellite to observe in more detail with specialized instruments. MOXE is a collaborative effort with Los Alamos National Laboratory. LHEA is providing much of the electronics and the ground support equipment. This RTOP supports the mission scientist for the X-Ray Multi-Mirror Telescope Mission, Dr. Richard Mushotzky. This RTOP also provides for accommodation of the Konus instrument into the ISTP/WIND project, and preparations for the operations and data analysis phase, including collaborative analysis of Konus data with other gamma burst instruments on WIND, Gamma Ray Observatory (GRO), and Mars Observer. Dr. Thomas Cline is the US Instrument Co-principle investigator, and manager. The interface electronics and test support is provided under contract by EER.

**W93-70300**
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.

Origins of Solar Dynamics

W93-70301 452-11-93
Ames Research Center, Moffett Field, CA.
INFRARED STUDIES OF PLANETARY DEBRIS AROUND YOUNG MAIN SEQUENCE STARS
F. C. Witteborn 415-604-5520
The objective of this RTOP is a comprehensive search for evidence of planet formation near young main sequence stars, focusing on the infrared signature of collisional debris associated with planetary accretion. Significant infrared excess is expected if as little as 1 percent of the planetary mass remains in an asteroid-micrometeroid size distribution. Our targets are nearby stars with ages known to lie between 0.01 and 100 Myr, plus older stars for comparison. The main goals of our program are an understanding of the variation of continuum flux excesses and spectral features diagnostic of solid circumstellar grains as a function of stellar age, and a determination of the fraction of young main sequence stars that have such circumstellar grains. The approach of the RTOP is planned observations consisting of broadband infrared photometric surveys of field and cluster stars, combining ground-based data with IRAS data, to be followed by spectroscopy of stars found to have significant thermal infrared excesses. The shape and strength of continuum excesses deduced from the photometry can be used to derive temperature (distance from star) and amount of circumstellar material. The identity and strength of spectral features can be used to characterize the particle composition sizes and collisional history. Planned theoretical work consists of models of grain spectra characteristic of collisionally altered material to be compared with spectra of material around candidate stars, and a rigorous study of stellar age indicators, allowing expansion of the sample of young stars for our observational program to include numerous and nearby field stars.

W93-70302 452-21-93
Ames Research Center, Moffett Field, CA.
PLANET-FORMING DISKS
P. Cassen 415-604-5597
The objective of this RTOP is to develop a predictive theory of the formation of protostellar disks and their physical and chemical evolution, and to relate these to the history of the primitive solar nebula. The approach used is to generate mathematical models of the physical processes that control interstellar cloud collapse, disk formation and disk dynamical evolution; derive the consequences of the modeled processes for the processing of interstellar material; and test the results by comparison with solar system data derived from the examination of primitive material.

W93-70303 452-22-91
Ames Research Center, Moffett Field, CA.
CONVECTIVE TRANSPORT IN THE SOLAR NEBULA
J. B. Pollack 415-604-5530

The goal of this RTOP is to calculate directly from the Navier-Stokes equations the local turbulent transport of angular momentum, mass, and heat due to thermal convection under the solar nebula conditions. These results will be used to test standard phenomenological models, to test the ability of convection to sustain itself through viscous heat release, and to develop better models as necessary. The global evolution of the solar nebula disk will be calculated from these models to determine its evolutionary timescale and structure due to turbulent convection. These results will be compared with recent observations of low-mass pre-main-sequence stars. More accurate predictions of grain coagulation rates will also be possible with the small-scale turbulence statistics. The approach is the use of hydrodynamic simulations of turbulent convective flow on NASA-Ames Cray supercomputers. The governing fluid equations are solved exactly for low Reynolds number flows, and flow statistics (space and time averages) are accumulated for statistically steady flows. These statistics provide direct determination of heat fluxes and Reynolds stresses, responsible for heat and angular momentum transport, and provide the basis for modeling such terms. High Reynolds number flows require large eddy simulation, in which the effect of the small scales is modeled. We will test the performance of subgrid-scale models for flow conditions relevant to the solar nebula and use successful models in large eddy simulations.

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

W93-70304 452-22-93
Ames Research Center, Moffett Field, CA.
TWO-PHASE NEBULAE
J. Cuzzi 415-604-6343
(151-01-60; 151-01-08)
The objective of this RTOP is to contribute to the understanding of the origin of the planets of the solar system, one of NASA’s most fundamental goals. Research is focused on modeling the accretion of particulates in the size range sampled by meteorites (microns to microns in particle radius) within a turbulent layer near the nebula midplane in which the dynamical influence of the particle and gas phases on each other is substantial, leading to a strongly coupled behavior of the system as a whole. The results obtained are of both immediate and long-term value to NASA in guiding extraterrestrial sample analysis (meteorites, interplanetary dust particles (IDP’s), Mars samples, comet nucleus samples) and astrophysical observations of extrasolar particle disks (Hubble Space Telescope (HST), Stratospheric Observatory for Infrared Astronomy (SOFIA), Space Infrared Telescope Facility (SIRTF)). The approach of this RTOP is to use theoretical modeling of the two-phase fluid dynamics of the particle-gas system to provide mean and turbulent flow states in which to implement particle coagulation calculations. Our coagulation calculations will incorporate theoretical studies of grain sticking for a variety of particle compositions (water, silicate, organic) and configurations (solid, fractal, and composite). Coagulation determines the evolution of the particle size distribution which will feed back into the fluid dynamics to influence the generation and damping of mean flows and turbulence. Ultimately radiative transfer, energetics, and simple chemical mixing will be incorporated in a self-consistent fashion.

W93-70305 452-23-94
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORIGINS OF SOLAR SYSTEMS
J. D. Goguen 818-354-8748
This group of research tasks addresses a range of modeling and simulation problems concerning the origins of solar systems. Specifically, characteristic features of the planetary accretion process are investigated, including density wave propagation during planetesimal interactions and a search for features that distinguish circumstellar disks containing protoplanetary objects. Models are developed for the dynamics of comet Oort clouds around field stars orbiting the galaxy within a realistic, changing dynamical environment. This study will elucidate possible structures for these comet clouds and, consequently, their detectability, with possible inferences for the existence of unresolved planets closer to the central star. Chemical models will be examined for the dense star-forming fragments of interstellar gas and dust clouds. The
physical and chemical conditions of such regions may help to explain the observed chemical abundances in our solar system and the origin of comets. The approach makes use of theoretical models of density wave disturbances in the study of planetary accretion processes, including a study of resonant trapping of planetesimals. Cometary Oort cloud perturbations are modeled using a computer-based simulation of the galactic dynamical environment. Finally, the approach includes the use of computer code of time-dependent interstellar ion-molecule chemistry.

W93-70306 452-33-93
Ames Research Center, Moffett Field, CA.

CHEMICAL EVOLUTION OF INTERSTELLAR ICES: THE CONNECTION WITH PRIMITIVE SOLAR SYSTEM MATERIALS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to increase our knowledge of chemical evolution and deuterium fractionation in interstellar ices and comets. These processes determine the raw material from which the solar system formed and are the link between organic matter in the solar system, comets, and meteorites. The approach of the RTOP is to prepare interstellar ice analogs and complex organic molecules in the laboratory under conditions simulating those in space. Their spectroscopic properties will be studied as part of the analysis of the materials produced by energetic processing. These materials will also be analyzed chemically to determine which specific compounds are made. Transmission electron microscopy will be made of the ices to determine the microscopic structures of the ice in order to understand how these structures mediate macroscopic behavior including gas release from comets.

W93-70307 452-89-91
Goddard Space Flight Center, Greenbelt, MD.

MANAGEMENT SUPPORT: ORIGINS OF SOLAR SYSTEMS RESEARCH PROGRAM
J. Nuth 301-286-9467

The purpose of this RTOP is to support the requirements of the Discipline Scientist for the Origins of Solar Systems Research Program at Goddard Space Flight Center (GSFC). NASA Headquarters provides the funds necessary to support the operations of the NASA Origins of Solar Systems Research Program Discipline Scientist at GSFC. Specifically, this provides money for support of a part-time scientific typist and data entry technician to prepare the procurement paperwork necessary to initiate NASA funding (through NASA Headquarters) for researchers selected through the Origins of Solar Systems NRA. This contractor provides up-to-date accounting information to the Discipline Scientist and types all correspondence and reports from the Discipline Scientist to both NASA Headquarters and the scientific community. This RTOP also provides the funds necessary to hire a part-time laboratory technician who handles some of the more routine laboratory experiments and equipment maintenance for the Discipline Scientist in recognition of the time spent by the Discipline Scientist in the day-to-day management of the Origins of Solar Systems Research Program for NASA Headquarters.

Radiation and Dynamic Processes

W93-70308 460-20-00
Marshall Space Flight Center, Huntsville, AL.

PROCESS STUDIES: RADIATION DYNAMICS AND HYDROLOGY, RADIATION AND DYNAMIC PROCESSES
R. J. Koczo 205-544-3078

The objective is to perform a series of studies to assess current remote sensing capabilities to study earth processes, develop aircraft-based prototype instruments to test future remote sensing concepts, and derive relevant geophysical parameters from these aircraft and space-based sensors which contribute to describing the radiational and dynamical processes associated with the earth system. The approaches are to utilize the talents of university and private contractor groups to assist in-house engineers in the development of aircraft remote sensing systems, utilize in-house expertise to assess these measurements, and derive the necessary geophysical parameters to describe the earth system.

W93-70309 460-21-00
Ames Research Center, Moffett Field, CA.

CO2 LIDAR BACKSCATTER EXPERIMENT
R. F. Pueschel 415-604-5254

The objective is to measure aerosol size distributions and particle shapes and composition simultaneously with the CO2 lidar measurements as a means of validating the lidars which will be precursors to the Doppler lidars planned for wind measurements from space (LAWS - Laser Atmospheric Wind Sounder). The approach is to fly impactors and laser aerosol spectrometers on the Ames DC-8 aircraft to measure the global variability in aerosol size distributions and particle characteristics. These measurements will contribute data needed for lidar backscatter calculations to assess the sensitivity of CO2 lidar for wind velocity measurements. Emphasis in FY-93 will be a final analysis and publication of data collected in GLOBE I and II mission flights.

W93-70310 460-21-28
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

IR REMOTE SENSING OF SST
D. E. Hagan 818-354-7073

The objective of the proposed work are to investigate and improve infrared methods of measuring sea surface temperatures (SST) from space, and to improve basic understanding of ocean boundary layer radiation and thermodynamic processes. The proposed measurements will determine the extent to which changes in SST modify the boundary layer radiation profile under high water vapor conditions, and will verify radiative transfer analyses which show the relationship between the atmospheric water vapor, air temperature, the ocean surface radiance, and boundary layer aerosol in the 10 to 12 micron region used for remote sensing purposes. As a second component of the research plan, the proposed measurements will improve the parameterization of the surface latent heat flux under conditions of low wind speeds and high atmospheric water vapor, and will help determine the extent to which variability in SST determines the scale of atmospheric response. The approach is to obtain aircraft-based, high precision multi-spectral radiometric measurements simultaneously with direct atmospheric flux measurements of heat, moisture and momentum. The radiance measurements will be obtained in several contiguous spectral passbands which cover the atmospheric window region and two spectral bands which closely resemble the spectral channels of present satellite sensors. Boundary layer vertical flux profiles, and measurements obtained over repeated aircraft surface tracks will be obtained under a variety of cloud and water vapor conditions in tropic latitudes as part of the TOGA Coupled Ocean-Atmosphere Response Experiment. The measurements will resolve: the small to mesoscale part of the SST structure; the small-scale variability of the temperature difference between the air and SST (an essential part of the heat and moisture fluxes); and the total effect of water vapor on SST measurements from space.

W93-70311 460-21-52
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AIRBORNE DOPPLER LIDAR
R. T. Menzies 818-354-3787
(460-22-53; 460-28-41)

The objective of this task is to develop and use an airborne Doppler lidar for measurements of atmospheric wind fields in regions of scientific interest, conducting specialized measurements of atmospheric dynamic processes over critical scales within the boundary layer and free troposphere. It is planned to utilize the Doppler lidar instrument while participating in intensive field observational activities of major atmospheric research programs.
planned for the 1990's. The range-gated lidar, coupled with scanning optics, will provide detailed spatial structure of various dynamic processes. This investigation consists of fabrication of an airborne Doppler lidar, in collaboration with groups from NASA Marshall Space Flight Center and National Oceanic and Atmospheric Administration (NOAA) Wave Propagation Laboratory, using a modified version of the existing JPL Airborne Backscatter Lidar (ABL) optics, optical table, and support framework. (NOAA will supply the pulsed laser transmitter, and MSFC will supply the transmit/receive telescope and the Doppler data processing capability.) The instrument will be designed for flights on the NASA DC-8 research aircraft, beginning in FY-95 or FY-96. Instrument integration and system tests will be performed at JPL. A hard target calibration procedure will be used to permit both ground-based and airborne measurements of atmospheric backscatter coefficients in addition to wind field measurements. The backscatter data obtained will be of value in the continuing study of atmospheric aerosol and cloud backscatter characteristics at infrared wavelengths.

W93-70312 460-22-52
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LIDAR TARGET CALIBRATION FACILITY
R. T. Menzies 818-354-3787
(460-22-53; 460-28-41)

The primary objective of the JPL Lidar Target Calibration Facility is to provide accurate and consistent calibration of lidar targets. Customers in the lidar community will each provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO2 laser wavelength, incident and reflected polarizations, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of hard target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. A secondary objective is to measure the depolarization properties and the proximity to Lambertian (diffuse) behavior of customer-supplied and experimental target surfaces. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a Lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to the primary standard, and the eventual field use of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce special effects. Continuity between the three measurements will include target continuity, illumination continuity - wavelength, polarization, and bandwidth; and geometric continuity - polar angles, solid angles, and target size to beam size relationship.

W93-70313 460-22-53
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ATMOSPHERIC BACKSCATTER EXPERIMENT
R. T. Menzies 818-354-3787
(460-22-52; 460-28-41)

The objective of this program is to support studies of the feasibility and scientific value of an Earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol and cloud backscatter coefficients at wavelengths in the 9 to 11 micron range over large geographical regions, emphasizing those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation consists of flights of an airborne (CO2) backscatter lidar (ABL) on the NASA DC-8 research aircraft, configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the surface or above the aircraft altitude. The ABL instrument has been flown on the NASA DC-8 on several missions over the Pacific Ocean. Southern Hemisphere measurements have also been made. The data obtained are analyzed and considered in the context of related instrument measurements of atmospheric aerosols, cloud cover statistics, and other atmospheric parameters. The data are intercompared with other lidar data in order to model the wavelength dependence of aerosol and cloud backscatter in the infrared. The ABL instrument will be flown in the next few years in its present form, and then it will be converted into a Doppler lidar, whose elements are being developed under a related task (RTOP 460-21-52).

W93-70314 460-28-41
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

WIND MEASUREMENT ASSESSMENT
R. T. Menzies 818-354-3787
(460-22-52; 460-22-53)

The objective of this program is to evaluate certain aspects of the Doppler lidar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurements of atmospheric wind velocities have been analyzed; e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared range-rated lidar, with the results indicating that the infrared Doppler lidar technique is the superior technique for tropospheric wind field measurements. During FY-93, the work will continue to add to the climatology of aerosol backscatter by further experimental study of vertical profiles of backscatter at CO2 laser wavelengths in the 9 to 11 micron region. An emphasis will also be placed on assessing the influence of visible and sub-visible cirrus on the backscatter to be expected, including seasonal dependence of probability of occurrence. The use of air parcel trajectory analysis capabilities at UCLA will be continued in order to study the dependence of aerosol backscatter on the history of the air parcel. Comparative performance analysis of the major types of Doppler lidar, including both incoherent and coherent detection, have been conducted and reported in the literature. These studies will be re-assessed as new data and new technology become available.

W93-70315 460-42-00
Ames Research Center, Moffett Field, CA.

RADIATIVE EFFECTS IN CLOUDS FIRST INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY REGIONAL EXPERIMENT
F. P. J. Valero 415-604-5510

The objective of this study is to determine the relationship between cloud microstructure and cloud radiation properties. Remote sensing measurements of cloud structure from the NASA ER-2 will be compared with in situ measurements from the Convair C-131.
The objectives of this RTOP are: (1) 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 1990 using Scanning Multichannel Microwave Radiometer (SMMR), Advanced Very High Resolution Radiometer (AVHRR), Thematic Mapper (TM), and Special Sensor Microwave Imager (SSMI/I) data; and (2) to 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 the period 1979 to 1990. Radiative transfer and heat balance models will be used with daily or monthly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices, and surface temperature. Methodology for correcting the satellite data for atmospheric effects will be developed. SMMR and SSM/I 37 GHz data will be compared. 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.
to provide regional
of the surface heat transfer; and (3) performing detailed
needed to initialize
should be able to develop the large-area surface
address the surface-to-atmosphere linkages of arid regions. This
Edwin T. Engman 301-286-5480
DESERT MESOSCALE/PBL
Goddard Space Flight Center, Greenbelt, MD.

(4) long wave, the magnitude of depolarization, and the
New Airborne Scatterometer (NUSCAT) during the Surface Wave
the quantitative relationship between radar backscatter from the
parameters such as near surface winds
to through airborne scatterometry experiments. The primary FY-93
objectives are to continue the analysis of the results obtained by
New Airborne Scatterometer (NUSCAT) during the Surface Wave
Dynamics Experiment (SWADE) in order to evaluate the effects of
long waves, the magnitude of depolarization, and the
intercomparison of Ku- and C-band backscatter behavior across the
Gulf Stream boundaries. A secondary objective is to continue
interacting with NASA Headquarters on the future disposition of
NUSCAT. In FY-92, we have completed the re-calibration of the
major components of the NUSCAT system. The radar
measurements were then converted to calibrated backscatter cross
sections. We have also identified three specific data sets for
detailed studies: (1) low wind data collected on 1 Mar. 1991; (2)
comparision of low and high wave situations; and (3) a collection
of Gulf Stream boundary crossings that had large changes of
air-sea temperature difference. In FY-93, we will complete these
studies and document the results in publications. We will also
conduct a detailed study of intercomparison between the Ku- and
C-band observations. In particular, we will examine the relative
sensitivity to wind speed changes and the upwind/
downwind/crosswind azimuth modulation depths. We will also perform an analysis of the cross-polarization measurements and
compare the level of depolarization observed to existing
electromagnetic scattering theories. Finally, we will interact with
NASA Headquarters on the disposition of NUSCAT.

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The improved data set will consist of high accuracy altimeter heights obtained by retracking the altimeter waveforms, an improved electromagnetic bias and altimeter mispointing corrections. The ultimate objective is to use the improved data set to investigate the characteristics of the global large-scale sea level variables.

In order to perform the altimeter waveform retracking, we have adapted the sub-optimal maximum likelihood algorithm developed for the processing of Geosat data to handle the characteristics of the two-frequency, differently sampled TOPEX waveforms, and implemented the algorithm in an operational system able to handle TOPEX data in real time. Prior to launch, the algorithm has been tested for accuracy and speed performance using Monte Carlo experiments. After launch, we will use the verification period to assess the accuracy of the retracked data, and to provide independent confirmation of the TOPEX performance. During the TOPEX mission, we will then use the high accuracy TOPEX data set to validate and improve the TOPEX electromagnetic bias height correction algorithm by using repeat track data and over NDBC buoys. Finally, we will generate a smoothed, interpolated, data set sampled at 10 day intervals to extract and estimate the seasonal cycle, and study the dynamics governing the variability of the residual signal by regression analysis and Kalman filtering.

W93-70327
Goddard Space Flight Center, Greenbelt, MD.

AIRBORNE ESTAR
David M. LeVine 301-286-8059 (462-26-01)

Salinity is a parameter of the oceans important for understanding ocean circulation and coupling to the global atmospheric and hydrologic cycles. Salinity can be measured with microwave radiometers using two channels (L- and S-band) to remove the effects of water temperature. However, measurements from space at these frequencies require large antennas to achieve adequate spatial resolution. The purpose of this research is to determine whether aperture synthesis can be used to achieve the required resolution with an antenna which is feasible to deploy from space.

W93-70328
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, ESA Remote Sensing Satellite-1 (ERS-1), and future altimeter missions. 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 Baseline Interferometry (VLBI), and to the Earth's center using the Global Positioning System (GPS) and satellite laser ranging. It is proposed that dual frequency L1/L2 GPS receivers collocated with altimeter transponders be deployed along the TOPEX/POSEIDON groundtrack. Through differential GPS geometric 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.

W93-70329
Goddard Space Flight Center, Greenbelt, MD.

TRMM
Otto W. Thiele 301-286-9006 (461-57-01; 461-57-26)

The objective of this RTOP is to participate in the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE) to make salinity measurements. The approach is to measure ocean salinity in the warm pool region of the western Pacific using a shipborne microwave radiometer.

W93-70330
Marshall Space Flight Center, Huntsville, AL.

HYDROLOGIC PROCESS STUDIES
R. J. Koczor 205-544-3078

The objectives are to perform a series of studies to assess current remote sensing capabilities to study earth processes and to study hydrologic processes using aircraft and ground-based instruments in various field programs. The talents of university and private contractor groups will be used to develop and measure hydrologic process through various field activities.

W93-70331
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

GEWEX PROGRAM SUPPORT
D. G. Vane 818-354-3708

The objective of this RTOP is to provide support to the NASA Global Change Program in: (1) developing the Global Energy and Water Cycle Experiment (GEWEX) for NASA; (2) planning for the GEWEX Continental-Scale International Project (GCIP); and (3) coordinating GCIP and GEWEX plans with the National Oceanic and Atmospheric Administration (NOAA) and other agencies.

W93-70332
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AIRBORNE PRECIPITATION RADAR
F. K. Li 818-354-2849

The objective of this task is to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. ARMAR will be used to verify the technique, technology and data processing algorithms for future satellite rain measurement missions, such as the planned Tropical Rainfall Measuring Mission (TRMM). It will also be used in the post-launch performance validation of such spaceborne rain radars. In FY-93, our primary objective is to conduct the first scientific rainfall measurement experiment with ARMAR during the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE). ARMAR will be deployed on the NASA Ames DC-8 from January to March 1993 for about ten flights over rain events near the intensive observation area of TOGA/COARE in conjunction with other airborne and in situ measurements. We will complete an initial assessment of this data set by the end of FY-93. This initial assessment will include an evaluation of the system calibration accuracy throughout the experiment, the quantity of useful data over significant rain events and any initial comparison with in situ measurements. The other objectives in FY-93 are to procure the antenna and RF components of the 24 GHz channel and to initiate the incorporation of this second channel into ARMAR after the TOGA/COARE deployment.
In FY-92, the 14 GHz channel of ARMAR was fully fabricated and was tested on the ground in two rain storms around Los Angeles in late 1991 and early 1992. There are now two sets of engineering test flights on the DC-8 planned in May and July of 1992. The system will return to the Jet Propulsion Lab (JPL) after these tests and any system refinement required based on these test results will be conducted in the remainder of 1992. We will also perform a complete, detailed system calibration based on laboratory as well as airborne measurements. The ground processing system will be fully checked out using these engineering test results. Modifications of the on-board processor to enhance the near real-time visibility into the data collection procedure will also be performed. The actual TOGA/COARE deployment will be in the first two months of 1993. ARMAR will be installed on the DC-8 in December 1992 and about ten data flights over the TOGA/COARE experiment area will be conducted. The radar data will be processed into backscatter and Doppler measurements based on initial system parameters in the remainder of FY-93. The long lead items of the RF and antenna components of the 24 GHz channel will be procured and installed after the TOGA/COARE deployment. The fabrication of this second channel will be completed in FY-94.

W93-70333
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROWAVE PROCESS STUDIES OF SEA ICE PROPERTIES
M. R. Drinkwater 818-354-8189 (665-35-10)

Using existing and forthcoming data, the goal is to establish a methodology for combining microwave images recorded at various frequencies and polarizations, in order to provide a dataset from which the geophysical properties of sea ice can be inferred. Aircraft, satellite, and in-situ microwave data will be combined, and used in conjunction with empirical and theoretical models to characterize and quantify scattering and emission responses to variations in ice properties. The ongoing study focuses on Arctic and Antarctic ice types controlling surface fluxes of heat and salt, for instance, thin or young ice forms. The objectives are: (1) to participate in the Polarstern Winter Weddell Sea Experiment from May to July 1992 to make shipborne C-band multichannel microwave scattering and surface property measurements; (2) to obtain simultaneous Earth Resources Satellite (ERS-1) and Japanese-ERS-1 satellite Synthetic Aperture Radar (SAR) images during the Antarctic experiment; (3) to evaluate optimal frequency and polarimetric discriminators for ice properties in combined multichannel active and passive microwave data; and (4) to continue model simulation comparisons with SAR and scatterometer data to derive signatures characteristic of new and young snow-covered first-year ice of varying properties in calibrated radar data. The approach is to continue: (1) analysis of polarimetric covariance matrix data to determine unique sources of independent snow and ice properties information; (2) refinement of segmentations of distributed target scattering scene into recognizable scattering tendencies of key ice types, by combinations of polarimetric classification and target decomposition; (3) to extend the active-passive analysis of colocated March '88 Arctic microwave data by addition of the C-band Sea transect and then multivariate analysis of this Arctic-wide multiple channel SAR, Airborne Multichannel Microwave Radiometer (AMMR), K-band Radiometer Mapping System (KRMS) dataset; and (4) to develop techniques for extraction of geophysical information by model inversion.

W93-70334
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLARIMETRIC DATA ANALYSIS
R. Kwok 818-354-5614

During March 1988, multi-frequency polarimetric radar data were collected in the Beaufort, Chukchi and Bering Seas with the Jet Propulsion Lab (JPL) airborne Synthetic Aperture Radar (SAR). These datasets can be used to obtain a better understanding of the scattering mechanisms of sea ice returns and extraction of features for discrimination of sea ice in polarimetric data as well as guide the design of classification algorithms for data from single frequency, single polarization radars. Preliminary investigations utilizing C-, L- and P-band polarimetric data have concentrated on ice type discrimination and characterization in the digital images. Results suggest that polarimetric data can significantly enhance our ability to distinguish between open water, new ice and thicker smooth ice. The long term goal is to identify the ice types that can be unambiguously labeled in the multi-frequency, polarimetric SAR data utilizing available datasets and ground truths. The approach of the proposed work is to characterize the multi-frequency polarimetric signatures of sea ice in the aircraft data acquired during the 1988 ARMAR campaign. The focus is on investigating the improvement of the discrimination capability of sea ice in the polarimetric data, the compilation of signatures of thin ice types in polarimetric SAR data, and characterization of the limitations of polarimetry using spaceborne sensors.

W93-70335
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CEMS: REMOTE SENSING TECHNOLOGY AND APPLICATIONS
D. Halpern 818-354-5327
The Oceanic Remote Sensing Library (ORSL) serves the research needs of JPL earth scientists involved in studies of ocean circulation, ocean-atmosphere interactions, biogeocycles, atmospheric sciences, oceanic chemistry, remote sensing technology, and climate and global change. With the high cost of periodical literature and with the large numbers of periodicals and technical reports, no individual investigator at JPL has adequate budget resources nor sufficient office space to acquire the necessary literature to conduct state-of-the-art research. ORSL maintains a collection of technical periodicals, reports, and books related to biological, chemical, and physical oceanography, atmospheric sciences, and relevant satellite missions. ORSL provides an efficient and effective circulation procedure. ORSL supports research activities of the oceanographers, including retrieval of scientific literature. ORSL provides an intellectually inspiring area with appropriate audio-visual equipment for meetings and conferences for small groups. ORSL maintains special collections of internal documents, which are available free-of-charge from universities, NASA Centers, ESA, WCRP, NOAA, and many other organizations. ORSL provides all library services to JPL researchers, including document retrieval.

W93-70336
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ICE SHEET GEOPHYSICAL INVESTIGATIONS USING IMAGING RADAR
F. D. Carisey 818-354-8163

The goal of this work is to investigate ice sheet geophysics using microwave synthetic aperture images in conjunction with surface observations. There is the very significant prospect that Synthetic Aperture Radar (SAR) observations can supply critical information on ice accumulation and ablation, ice motion and snow and firn properties. Seasat first collected SAR images, and they have raised a number of scientific questions relating to the opportunities of SAR with respect to the monitoring of glacial hydrology and ice sheet geophysics. High resolution Jet Propulsion Lab (JPL) multiple-channel airborne SAR datasets collected in 1989 and 1991 over Greenland form the basis for interpretation of future Earth Resources Satellites (ERS-1) and Japan's ERS-1 satellite imagery and for the development of future observation systems. The objectives of this RTOP are: (1) Extract key surface features such as distinct snow regimes and drainage patterns from the imagery; (2) Assess present utility and optimize SAR data products and develop techniques to investigate the penetration of the SAR wavelengths into the ice sheet surface and to determine the consequences to SAR processing from the penetration along with SAR data analysis tools; and (3) Develop methods to extract local topographic effects from radar imagery by data fusion with altimetry data, digital terrain model and other satellite data. The approach is to: (1) Process and analyze multi-channel airborne synthetic aperture radar (AIRSAR) data acquired in August 1989 and June 1991, during transit flights over the southern Greenland ice cap; (2) Optimize SAR data products and generate and distribute to the glaciological community a calibrated Greenland high resolution
The objective of the present research is to develop a technique to create the ice sheet image dataset for polarimetric analysis along with SAR data analysis tools; (3) Conduct a polarimetric analysis of the backscatter signatures observed from different snow and ice facies; (4) Plan and conduct an Antarctic flight campaign to image critical ice sheet areas with significant surface measurement programs, as part of planned deployment of AIRSAR to Australia in 1993; and (5) Support ERS-1 and Japan's ERS-1 data acquisition over Greenland and Antarctica.

Ecosystem Processes

W93-70337 462-21-00
Ames Research Center, Moffett Field, CA.

FOREST/CLIMATE INTERACTIONS
D. L. Peterson  415-604-5899
The goal of this research is to test the extent of which stand-level models of forest evapotranspiration and net primary production can be extrapolated to regional scales. Under development is a computer simulation system to conduct these tests. The input fields to the model consist of important environmental variables such as surface temperature, precipitation, soil type, and leaf area index. The process model is based on FOREST-BGC, developed by Dr. S. Running and J. Coughlan (University of Montana) and MTN-CLIM, a meteorological model developed for mountainous terrain, also developed at Montana. The output fields generated by the model include photosynthesis and evapotranspiration. The simulation system, formerly called the Regional Ecosystem Simulation System (RESSYS), was recently renamed to the Regional Hydroecological Simulation System (RHESSYS) to reflect the fact that a hydrological routing model was added to the system. The hydrological module, a version of TOPMODEL by Beven and Kirby (1979) modified by L. Band and his collaborators at the University of Toronto, moves water from one spatial unit to its neighbors depending on its slope and soil parameters. Current work is focused on the improved parameterization of input fields using geostatistical methods, and on the development of a modelling assistant to provide an environment for building and modifying a scientific model. The latter will be used for modifying or redesigning the process model for RHESSYS.

W93-70338 462-26-01
Goddard Space Flight Center, Greenbelt, MD.

SYNTHETIC APERTURE MICROWAVE RADIOMETER
David M. Levine  301-286-8059 (481-38-01)
Soil moisture is a highly variable element of the hydrologic cycle which is important in understanding the global hydrologic cycle and its coupling to the atmosphere and effect on climate as well as being important in agricultural management. Surface moisture can be monitored from space using radiometers operating at the low end of the microwave spectrum (e.g., L-band) because of the strong dependence of the dielectric constant of soil on its moisture content and the ability of radiation at these wavelengths to penetrate vegetation. However, the long wavelengths mean that large antennas are needed in orbit to obtain global maps of soil moisture. This research is to develop a technique to create the required large antenna apertures, synthetically, using pairs of small antennas and signal processing. The technique is called aperture synthesis and involves making measurements with pairs of antennas at many different antenna spacings. The technique has been successfully demonstrated using an aircraft prototype instrument developed in previous research in this program. (The prototype is a hybrid instrument which obtains resolution along-track using real antennas and resolution cross-track using aperture synthesis.) The objective of the present research is to calibrate the instrument and validate its performance through participation in hydrologic field experiments.

W93-70339 462-31-63
Goddard Space Flight Center, Greenbelt, MD.

LASER INDUCED FLUORESCENCE: A TECHNIQUE FOR REMOTE ASSESSMENT OF PHOTOSYNTHETIC EFFICIENCY AND DETECTION OF ENVIRONMENTAL STRESS
Emmett W. Chappelle  301-286-6638
The objectives of our investigations are: (1) the development of the Laser Induced Fluorescence (LIF) technique as a means of assessing photosynthetic efficiency at leaf and canopy levels; (2) detection of environmental damage to vegetation as evidenced by changes in fluorescence spectra; and (3) development of algorithms using reflectance spectra for the remote estimation of the plant constituents involved in photosynthesis. LIF and reflectance measurements will be made on greenhouse plants which will be grown under different levels of nutrient stress in order to obtain a range of physiological states which will insure different rates of photosynthesis and different pigment concentrations. Field measurements comparable to those made on the greenhouse plants will be conducted on plant canopies.

W93-70340 462-32-00
Ames Research Center, Moffett Field, CA.

LAND SURFACE CLIMATOLOGY: HAPEX
M. A. Spanner  415-604-3620 (462-31-62)
The objective of this work is to participate in the Hydrologic Atmospheric Pilot Experiment (HAPEX) in Niger in 1992. Ames Research Center participation will involve the measurement of aerosol optical properties from ground and aircraft Sunphotometers, examination of the variability and characteristics of the aerosols, and correction of remotely sensed data acquired during the experiment for atmospheric effects.

W93-70341 462-32-03
Goddard Space Flight Center, Greenbelt, MD.

VARIATIONS OF SOIL MOISTURE AND OTHER SURFACE PARAMETERS DURING HAPEX-SAHEL EXPERIMENT
Bhaskar J. Choudhury 301-286-5155
The objectives are to evaluate spatial and temporal variations of soil moisture during the HAPEX-Sahel experiment, and the synergism between multispectral observations (visible, near-infrared, infrared and microwave emission at 37 GHz) for estimating vegetation characteristics. The approach employs aircraft observations along transects over the HAPEX-Sahel test area following rain storms using the Push Broom Microwave Radiometer (PBMTR) at 1.4 GHz frequency to estimate spatial and temporal variations in soil moisture. Concurrent aircraft observations by the Thematic Mapper simulator (NS001), Thermal Infrared Multichannel Scanner (TIMS), and dual polarized 37 GHz radiometer will be analyzed through radiative transfer models to estimate vegetation characteristics, which will be compared against ground measurements.

W93-70342 462-32-61
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ECHIVAL FIELD EXPERIMENT IN DESERTIFICATION-THREATENED AREA (EFEDA)
D. L. Evans 818-354-2416
The objectives are (1) to develop the area-averaged parameterization of the water and energy transfer between soils, vegetation and atmosphere within the ECHIVAL Field Experiment in Desertification-Threatened Area (EFEDA)-Spain study site; (2) to estimate surface soil and vegetation parameters from Synthetic Aperture Radar (SAR) and other remote sensing data; and (3) to estimate the evapotranspiration over the entire EFEDA basin using parameters estimated from remote sensing data. The main focus is on the estimation of the evapotranspiration of the EFEDA site by using parameters derived from SAR and other remote sensing data. Our approach can be summarized as follows. (1) We propose to use the unsupervised classification algorithm developed by van
Zyl (1989) to distinguish between bare and vegetated areas in the EFEDA basin and to generate classified images based on the level of volume, surface, and double-bounce scattering mechanisms. (2) The inversion algorithms developed at the Jet Propulsion Laboratory (JPL) for inferring soil moisture and vegetation water content will be improved to include various agricultural crops. The algorithm will be applied to SAR data and images of estimated parameters will be generated. (3) We will use the estimated parameters from SAR data and other remote sensing information to calculate the evaporotranspiration from the surface. We will adjust the scale of the parameters and will generate maps of evaporotranspiration over the entire basin.

W93-70343 462-41-61
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SATELLITE RADAR FOR FOREST STRUCTURE
J. B. Way 818-354-8225 (579-41-08)

Multitemporal measurements of forest ecosystems may be critical in resolving ambiguous interpretations of microwave backscattering from architectedly 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 variations from phenologic development. In addition, changing seasonal environmental conditions enhance or subdue certain components of the radar backscatter. The key questions being addressed in this study are: (1) how do the magnitudes of seasonal variation in the microwave backscattering coefficient as a function of wavelength and polarization vectors in response to naturally occurring temporal variability in monospecific forest stands which are characteristic of the temperate deciduous and coniferous forests and boreal forests; (2) how are these variations in the backscatter coefficient quantitatively related to specific forest stand and environmental properties via the relevant scattering mechanisms; (3) can SAR data be adequately calibrated (in both a relative and an absolute sense) to permit use of the data in conjunction with microwave scattering models, to permit its use in multitemporal comparisons and to permit site to site comparisons of globally distributed forests; and (4) given the observed temporal variations in backscatter, what ecologically useful information can be inferred from multitemporal SAR observations. To address the above questions, we are using multi-season ERS-1, JERS-1, and AIRSAR data sets of sites in the U.S. including the Bonanza Creek Experimental Forest in Alaska, the Duke University Research Forest in North Carolina and the Michigan Biological Station in Michigan.

Ground truth measurements collected simultaneously with the aircraft and satellite data are being 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, freeze-thaw, stress from frost, drought, and flooded conditions have been obtained in Alaska, summer drought stress and flooded conditions have been obtained over Duke, and winter snow and summer rain/no-rain data sets have been acquired with Michigan with AIRSAR. Approximately 50 ERS-1 scenes have been obtained over both Michigan and Alaska between summer and winter of 1991. Additional data sets will be acquired through 1994.

W93-70344 462-43-00
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL CYCLING RESEARCH ON THE OREGON TRANSECCT
D. L. Peterson 415-604-5899 (199-30-72)

The objectives of this project are to measure the processes of carbon, nitrogen and water cycling through terrestrial ecosystems and to develop the principles of how nitrogen and water interact to control carbon assimilation and allocation in intact ecosystems. The approach is to test an existing ecosystem model of carbon, nitrogen and water fluxes and interactions through a combination of field and remote sensing studies during an intensive multisensor aircraft campaign. This test of principles, involving surface climate, nutrient cycling and remote sensing, will be used to specify minimum general measurements. These techniques will then be expanded to companion sites the following year, and to support a workshop in the third year. Sensor data from a Canadian instrument, the Fluorescence Line Imager, will be added to the data set.

W93-70345 462-43-00
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
D. L. Peterson 415-604-5899 (462-43-00)

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 disturbances 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. 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.

W93-70346 462-61-00
Ames Research Center, Moffett Field, CA.
OPTICAL SCATTERING OF PLANT CANOPIES
V. C. Vanderbilt 415-604-4254

The objective of this project is to determine the relationships between the polarized light scattering characteristics of leaves and plant canopies and the biological properties of the leaf/plant such as plant development stage and leaf relative water content. The effect of the atmosphere on polarized light from plant canopies will be investigated. The approach involves studies conducted at three levels - laboratory, field, and aerospace. In the laboratory and field phases of the research, both single leaves and plant canopies will be measured allowing comparison of their spectral polarized light scattering properties and their physiological and morphological characteristics. The aerospace portion of the research will be conducted with the aid of a specially modified polarization scanner which will be flown on the ER-2. Targets of known light scattering characteristics will be measured on the ground and from the ER-2, thereby allowing the effect of the disturbing atmosphere to be better understood and modelled.

W93-70347 462-61-03
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HETEROGENEOUS SCENE MODELS
D. J. Diner 818-354-8319

Quantitative studies of the surface from space require the ability to infer accurate spectral reflectances, bidirectional reflectance distributions, and hemispherical albedos from top-of-atmosphere (TOA) radiances. The purpose of this RTOP is to develop and test practical methods for retrieving these land surface (and required atmospheric) properties which meet the accuracy requirements of the scientific community and apply these methods to multi-angle image data sets currently available. We have the following objectives: (1) development of surface reflectance retrieval algorithms; (2) development of atmospheric optical property retrieval algorithms; (3) validation of these algorithms through experiments. These techniques will then be expanded to companion sites the following year, and to support a workshop in the third year. Sensor data from a Canadian instrument, the Fluorescence Line Imager, will be added to the data set.
retrievals are based on this formalism. Our radiative transfer-based retrieval code currently includes surface reflectance heterogeneity and directional properties. Our approach to retrieval of atmospheric aerosol optical properties (opacity, single-scattering albedo, and size distribution parameter) is dependent on the information content of off-nadir imagery. Our radiative transfer codes are able to compute the necessary nadir and off-nadir angle ray transformation fields associated with the retrieval algorithms and therefore we are able to model realistically the ASAS image data. A long term objective is to apply our techniques to EOS instruments, particularly the Multi-angle Imaging SpectroRadiometer (MISR).


**RADAR SCATTERING INVERSION: FORESTED AREAS**

H. A. Zebker 818-354-8780

The specific objective of this study is to improve our understanding of the interaction of radar signals with forested terrain, with the goal of developing algorithms permitting the inversion of remotely-sensed radar measurements to solve for geophysical factors describing the various forest canopies around the world. Specifically, we will first address the issue of biomass estimation, important for carbon cycle modeling. Previous theoretical modeling has indicated that the measured radar cross section is dominated by various scattering mechanisms depending on forest parameters such as branch, leaf, and trunk density, dielectric constant and height of trees, and roughness and permittivity of the forest floor. Therefore, it should be possible through radar measurements to recover the quantities that enable us to define the physiological state of the forest in terms of the canopy structure and vegetation composition, and also to investigate its dynamical behavior as a function of varying temperature, precipitation, and other atmospheric effects. Our modeling approach is to use a layered discrete scatterer model, in which each scatterer such as a twig or leaf is individually modeled, then combined statistically with other scatterers to form the aggregate radar interaction model corresponding to a layer of scatterers. These layers are then combined as required to completely describe the backscatter process from that modeled forest. The advantages of this approach are that the number of layers may be varied to account for different forest structures, and that the predicted scattering is quite well related to individual densities of the scattering elements (branches, leaves, trunks, and the like). A sensitivity study carried out using our forward scattering model has shown that radar backscatter cannot directly be used to determine biomass uniquely, since (1) as the biomass increases, the radar measurements saturate at all frequencies, and (2) before saturation, the increase in measured cross section is not uniform, i.e., a change in biomass does not guarantee a change in cross section. The latter is due to nonuniqueness in the set of forest parameters producing the same radar measurement. The same study, however, has shown that the radar measurements at all frequencies are sensitive and related to dielectric constant, density, and size of trees over reasonable ranges. It is the goal of this study to determine these ranges and produce workable inversion algorithms.


**SOIL MOISTURE FROM SAR**

S. S. Saatchi 818-354-1051

The purpose of this investigation is to optimize the use of active and passive microwave remote sensing measurements for inferring soil moisture information. This study concentrates on the estimation of soil moisture in agricultural crops and grass fields. We propose to develop and calibrate backscatter and emission models for vegetated canopies and combine these models in order to make use of both active and passive data sets. The final combined model will be used to develop an inversion algorithm in order to use the Jet Propulsion Laboratory (JPL) Airborne Synthetic Aperture Radar (AIRSAR) and NASA Push Broom Microwave Radiometer (PBMR) images and retrieve soil moisture. We propose to participate in field campaigns such as MACHYDRO-90, ECHIVAL (European International Project on Climate and Hydrological Interactions between Vegetation Atmosphere and Land Surfaces) Field Experiment in Desertification Threatened Areas (EFEDA) in Spain, and MACHYDRO-92 in Oklahoma. The data collected in these experiments will be used to test our algorithm.

**W93-70350** 462-74-01 Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AIRBORNE INTERFEROMETRIC TOPOGRAPHY**

H. A. Zebker 818-354-8780 (465-67-04)

The specific objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objectives here are to implement such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer mode on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar RF switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce better than 2 m height accuracy DEM's with precision, co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in a manner that will allow it to be operated in a routine manner, should NASA wish to fund it as part of the AIRSAR system. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.


**AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS**

J. J. vanZyl 818-354-1365 (465-68-01; 685-81-08)

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parameterizing surface physical characteristics. In addition, this work serves to develop engineering methods that can be and are used to fabricate spacecraft Synthetic Aperture Radar (SAR) systems. AIRSAR is a three-frequency (P-, L- and C-band), fully polarimetric SAR that acquires all twelve data channels simultaneously, resulting in co-registered images at all frequencies. In FY-93, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and the Jet Propulsion Laboratory (JPL). Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SAR's. The plan is to reduce the data from up to 600 scenes to three-frequency imagery, each with four polarizations (12 images). System evaluation will be carried...
The overall objective of this RTOP is to advance the science of thermal infrared remote sensing. This objective will primarily be achieved through the use of image data acquired with the Thermal Infrared Multispectral Scanner (TIMS). The science support task described in this RTOP is divided into two elements: (1) operations and user support; and (2) instrument support. The Jet Propulsion Laboratory (JPL) will serve as the point of contact for active and future TIMS investigators, assist in the planning of TIMS missions, maintain a library of operation logs and flight reports, and maintain a library of color-composite TIMS images to serve as browse products. In addition, JPL will continue to host the annual TIMS Airborne Geoscience Workshop, maintain a laboratory spectrometer facility for the use of TIMS investigators, and distribute historic TIMS data held in the JPL tape archives. This last duty will be phased out during FY-93 as the United States Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center (EDC) assumes the responsibility for distributing historic TIMS data under Version 0 of Earth Observation System Data and Information Systems (EOSDIS). JPL will continue to monitor the performance of the TIMS instrument, conduct field calibration exercises, and design algorithms for the reduction and analysis of TIMS data. Beginning with the FY-92 flight season, JPL will receive copies of the data from all TIMS missions flown out of the NASA/Ames Research Center (NASA investigators will continue to receive their data directly from AMES). These data will be used to evaluate the performance of TIMS: (1) the housekeeping data recorded onboard the TIMS data tapes will be examined; (2) the digital numbers (DN's) recorded by TIMS will be reduced to radiance values and these values will be examined; and (3) decorrelation stretches (a contrast enhancement algorithm) of the TIMS data will be examined to evaluate instrument noise. Following the performance evaluation, the decorrelation-stretch images and radiance data products will be sent to the appropriate principal investigators. The new JPL thermal infrared calibration (TIRCAL) facility will be used to evaluate the spectral and radiometric response of TIMS. Field calibration exercises will be conducted near Castaic Lake and the Salton Sea, which are both easily accessible from JPL.
spatial and temporal distributions and variability of the planktonic community in the sea and of the primary productivity of that community on seasonal to interannual time scales and regional to global spatial scales, and the description of the coupling between the phytoplankton populations of the surface mixed layer and the physical environment of the near-surface waters. The objectives will be achieved through the use of remote sensing for a description of the near-surface radiance and irradiance fields, pigment concentration, the sea-surface temperature, and the incidental solar irradiance. We will extend our present research in the modeling of marine primary productivity through a description of the carbon flux in the near-surface waters. We will continue the verification of the model through the comparison of the model results with existing data bases in selected regions representing differing oceanographic environments. Presently we are using remotely sensed data for the description of the seasonal variability of the water column primary productivity of the global ocean and exploring the spatial and temporal distributions of phytoplankton biomass, primary productivity, and carbon flux in the equatorial Pacific Ocean upwelling area and in the oligotrophic central Pacific gyre in conjunction with the U.S. Joint Global Ocean Flux Study (JGOFS) activities in these regions. These studies include an analysis of the Multichannel Sea Surface Temperature (MCSSST) and Coastal Zone Color Scanner (CZCS) pigment imagery to describe a time series of pigment and temperature in the global ocean. This research utilizes the techniques of neural nets for the spatial and temporal interpolation of the satellite derived data fields.

**W93-70358**

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, phycocerythrin, and phycocyanin pigment and dissolved organic matter. Our approach is to focus efforts upon: (1) continued cooperative field investigations with widely-recognized oceanographic institutions, government laboratories, and field centers; (2) continued improvement of the airborne pulsed laser measurement of subsurface scattering layers using the AOL; and (3) direct application of active-passive correlation spectroscopy (APCS) to AOL data for advanced ocean color satellite sensor band selection and algorithm development. Specifically, continue/-initiate interagency cooperative oceanographic field investigations such as: (1) the Joint Global Ocean Flux Study (JGOFS), NOAA/NSF Climate and Global Change Program; and DOE's new Ocean Margins Program and Global CO2 Survey in the Ocean Program; (2) improving the temporal/depth-resolved electro-optical components of the AOL to allow the detection and quantitative measurement of particulate volumetric backscatter over a wide range of signal levels; (3) participating in the JGOFS Central Equatorial Pacific Experiment and data analyses; and (4) conducting 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 satellite sensor and the satellite Sea-Viewing Wide Field Sensor (SeaWIFS).

**W93-70359**

Ames Research Center, Moffett Field, CA.

**Regional Carbon Flux in High Latitude Ecosystems**

G. P. Livingston 415-604-3232

(145-90-00)

This research addresses the regional-seasonal estimation of carbon flux and the regulatory exchange processes for select northern high-latitude ecosystems. The approach is through integration of in-situ flux observations, simulation modeling, and land surface stratifications based upon satellite and aircraft remote sensing. Initial surface observations will determine the magnitude and variability of methane and carbon dioxide emissions along select environmental gradients to characterize the regulatory biogeochemical processes. Net emissions will be estimated within ecological spatial strata derived from SPOT, TM, AVHRR, SAR and CIR photography. Various estimation approaches of regional flux will be assessed based upon chamber, eddy correlation, and isotopic analyses of emissions, sampling and geostatistical theory, and the remote sensing derived strata. Surface flux measurements coupled with multitemporal coregistered AVHRR data will provide the basis for an assessment of the seasonal variability of carbon flux for Arctic tundra ecosystems. Various sources of error in the regional-seasonal estimates will be identified and their contribution to the overall estimated precision evaluated. The significance of high latitude ecosystems in the global carbon budget will be addressed through atmospheric modeling using existing photochemical models developed at ARC.

**W93-70360**

Goddard Inst. for Space Studies, New York, NY.

**Paleoecological Studies of CH4 Emissions**

Dorothy Petet 212-678-5587

The general objectives are to trace the postglacial development of the present distribution of peat bogs at mid-high latitudes using transects across Alaska, Canada, and the major peatland region of the Soviet Union. The relationship between areal extent of peatland to biogeochemical cycles on a global scale will be made by comparison of the timing of subarctic peatland formation in these regions with the timing of natural variations in atmospheric methane concentrations from ice core data. High latitudes not only are thought to play a role in driving climate change, but are sensitive reflectors of change at present. The relationship of peatland formation to climate change will be determined by comparing the peatland stratigraphy and chronology with independent glacial history of these regions and palynological and macrofossil data in the sediment cores. Peatland sections from coastal Alaska (1989), inland Alaska (1990), and coastal western Siberia (1992) are presently being analyzed for macrofossils and submitted for precise C-14 chronology. The 1992-93 field research will expand this objective to Canada and the USSR.

**W93-70361**

Ames Research Center, Moffett Field, CA.

**Biogeochemical Research in Tropical Ecosystems: Mechanisms of Trace Gas Production**

P. A. McElroy 415-604-6884

(462-43-00)

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, methane, carbon dioxide, and other gases in a range of ecosystems 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 land use type, climate-moisture characteristics, and canopy characteristics, will be tied to remote sensing techniques for extrapolation to regional and global scales.

**W93-70362**

Langley Research Center, Hampton, VA.

**Biospheric/Aerospheric Interactions**

W. R. Hook 804-866-6055

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

W93-70363
Ames Research Center, Moffett Field, CA.

BIOGEOCHEMICAL RESEARCH IN TEMPERATE ECOSYSTEMS
M. A. Spanner 415-604-3620 (462-43-00)
The objectives of these projects are to model the processes of carbon, nitrogen, and water cycling through temperate coniferous forests 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 using a database derived from a combination of field and remote sensing studies from optthermal transient radiometry (OTTER). The database developed from the OTTER data will be used to drive models over large geographic regions, provide tests of spatial subsampling and scaling, and assess land disturbance effects.

W93-70364
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AVIRIS OPERATIONS
R. Q. Green 818-354-9136 (465-65-01; 665-81-08)
The objective is to support the activities required to acquire, calibrate and distribute data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) for NASA sponsored science investigators in fiscal year 1993. AVIRIS measures the total upwelling radiance incident at the sensor in 224 channels with nominally 10 nm spectral sampling and 10 nm spectral response function (FWHM) from 400 to 2500 nm in the electromagnetic 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. All distributed AVIRIS data are calibrated with respect to spectral, radiometric and geometric characteristics. A brief summary of the AVIRIS operations assumptions for fiscal year 1993 are as follows: (1) Routine and preventative maintenance will be undertaken such that no degradation in performance occurs; (2) For 6 contiguous months AVIRIS will be at JPL for preventative maintenance and refurbishment following the 1992 flight season; (3) The following data acquisition deployments away from JPL will be supported (a) 14 weeks at Moffett Field, CA, and (b) two 3-week deployments to Wallops Island, VA; (4) Up to 1000 calibrated AVIRIS scenes will be distributed to sponsored investigators; and (5) Cost estimates for transportation of AVIRIS and travel to support launch site operations are based upon FY-92 travel and shipping costs. The objectives will be fulfilled through the following activities at JPL: (1) AVIRIS task and RTOP management; (2) calibration and validation science; (3) experiment coordination and mission planning; (4) data decommutation, calibration and distribution; and (5) sensor operations, calibration and maintenance.

Atmospheric Processes

W93-70365
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OZONE MEASUREMENTS
J. J. Margitan 818-354-2170
Vertical profiles of ozone in the stratosphere will be measured by a dual channel UV photometer flown as part of research balloon flights. Ozone profiles will be obtained on ascent and descent with 1 second (better than 100 meters) resolution. These data will serve as a comparison to other in situ and remote sensing techniques. This research effort is a collaborative project with the NOAA Aeronomy Laboratory. The ozone data will be useful in improving our understanding of stratospheric chemistry, and in particular in assessing the degree of discrepancy between measurements and calculations of ozone near 40 km. Ozone measurements will also be made aboard NASA's high altitude research aircraft. This research will be a part of the UARS (Upper Atmosphere Research Satellite) Correlative Measurements Program.

W93-70366
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LASER DIODE SENSOR
C. R. Webster 818-354-7478
The Ballon-Borne Laser In-Situ Sensor (BLISS) and Aircraft Laser Infrared Absorption Spectrometer (ALIAS) tasks have as their primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of changes in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDL's) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines up to a 1-km absorption path. The TDL beam in use is stabilized onto the retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity, throughout a diurnal cycle, and with the additional possibility of altitude profiling. The current measurement capability includes NO, NO2, O3, HNO3, HCl, H2O, CH4, N2O, CO2, and minor gas isotopes. A compact version of this instrument has been designed and built and has recently flown on the ER-2 aircraft as part of the 1991/92 AASE-II campaign out of Alaska and Maine, during which ALIAS provided part-sub-per-billion sensitivity measurements of HCl, CH4, and N2O. The ALIAS instrument employs a multipass gas cell with measurement capability for NO2, N2O, HCl, CH4, H2O, and HNO3.

W93-70367
Ames Research Center, Moffett Field, CA.

AIRBORNE IR SPECTROMETRY
S. Wegener 415-604-6278
The objective is to obtain information on the spatial and temporal distribution of stratospheric constituents for use in testing current theories of stratospheric chemistry, especially ozone depletion. The approach is to deploy infrared (IR) absorption and emission spectrometers on balloons, aircraft, and selected ground observations in coordination with other experimenters in order to identify constituents and infer concentrations from spectra obtained.

W93-70368
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

IR SOLAR ABSORPTION SPECTRA
G. C. Toon 818-354-8259 (464-16-01)
The objective is to obtain high resolution near-infrared solar spectra from which the abundance of many atmospheric minor constituents can be quantified. From these spectra, recorded at different latitudes in both hemispheres and at different seasons, the abundance of over 30 different gases can be measured simultaneously. These spectra also form a historical archive of the state of the atmosphere and will be re-analyzed as improved spectral parameters and retrieval software become available. Analyses of the data obtained from the measurements made in the course of this research meet the objective of establishing the present compositional state of the atmosphere. On a yearly basis retrieved gas abundances are compared with previous measurements in order to evaluate trends, and also with computer model predictions in order to assess their accuracy. Particular emphasis is being placed on chemical processes of current international interest, such as the depletion of the ozone layer. The approach taken to meet the science objective is to measure the spectral absorption of solar radiation by the atmosphere over the entire 2 to 16 microns spectral region using a Fourier Transform
Spectrometer, the JPL MARK IV Balloon Interferometer. Measurements have been and will continue to be made from various platforms including stratospheric research balloons, aircraft, and ground-based sites at locations of widely varying latitudes such as the Arctic, the tropics, and the Antarctic regions.

W93-70369 464-12-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MM AND SUB-MM RADIOMETRY
R. A. Stachnik 818-354-1921
(464-16-01)

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

W93-70370 464-12-15
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

FAR INFRARED BALLOON RADIOMETER FOR OH
H. M. Pickett 818-354-6861

A high resolution radiometer will be employed for stratospheric balloon observations of the hydroxyl radical in the far infrared region. The instrument uses three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101 cm\(^{-1}\) (99 microns). The resolution is 0.0017 cm\(^{-1}\) to match the width of the stratospheric emission lines. The instrument has the sensitivity for retrieving useful OH mixing ratio profiles between 25 km and 46 km with 3 km vertical resolution. Column density of OH above 46 km is also determined. The instrument is compact (0.36 cu m), lightweight (100 kg), and requires low power (45 W) and thus is well-suited to balloon observations.

W93-70371 464-13-15
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NDSC DIFFERENTIAL ABSORPTION LIDAR
I. S. McDermid 619-249-4262

The primary objective is to provide long-term records of the atmospheric ozone concentration and temperature profiles from both the facility already established at JPL's Table Mountain Facility in Southern California and from the new Network for the Detection of Stratospheric Change (NDSC) facility to be established at Mauna Loa Observatory in Hawaii. These measurements, which will become part of the NDSC database, will aid in the detection of changes in the ozone profile and provide information to help understand such changes. In the short term, these lidars are participating in the Correlative Measurements Program for the Upper Atmosphere Research Satellite (UARS) by making comparative, ground-truth, ozone, and temperature measurements for the UARS instruments that also measure these profiles. Since the eruption of Mt. Pinatubo in Jun. 1991, extensive data on the volcanic aerosols in the stratosphere have also been obtained. The approach used to measure ozone profiles is that of differential absorption lidar (DIAL), which uses two laser wavelengths to probe the atmosphere. For stratospheric measurements high laser energies are required and these are provided by a xenon chloride excimer laser that operates at 308 nm. Raman shifting of the excimer laser gives the reference wavelength at 353 nm which is also used in the temperature measurement. Two telescopes of 90 and 100 cm aperture are used to collect the laser radiation backscattered from the atmosphere for the TMF and MLO systems. The stratospheric ozone lidar at TMF has been in routine operation since 1988 and has made more than 450 independent ozone profile measurements. This system has also participated in a number of intercomparison campaigns, culminating in the extremely successful 1989 STOIC campaign, which have proved the quality of the results from this lidar. During the last two years, a new stratospheric ozone lidar has been under development for inclusion in this program at Mauna Loa. This system will be in full operation in FY-93. The program goals for FY-93 are: (1) to continue to make measurements of ozone and temperature profiles on a regular and frequent basis at TMF; (2) to complete the installation of the new stratospheric ozone lidar at Mauna Loa and to commence a measurement program similar to that at TMF; (3) to use all of the lidars to participate in the UARS Correlative Measurements Program; and (4) to continue to participate in intercomparisons and other developmental activities in support of the NDSC.

W93-70372 464-13-22
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NDSC MICROWAVE INSTRUMENT SUPPORT
I. S. McDermid 619-249-4262

The objective of this task is to continue to support the operation of the Network for the Detection of Stratospheric Change (NDSC) microwave radiometers for routine measurements of stratospheric ozone and water vapor profiles. A 100 GHz ozone radiometer, developed by Millitech Corporation for the NDSC, was installed at TMF in June 1989. The Principal investigators for this instrument are Alan Parrish, of Millitech and the University of Massachusetts, and Brian Connor of NASA LaRC. The millimeter-wave ozone instrument consists of a cryogenically cooled, single sideband, heterodyne radiometer, tuned to 110 GHz, and a multi-channel filter spectrometer. A second microwave radiometer, for measurements of water vapor, was developed by the Naval Research Laboratory and was installed at TMF in June 1991. The Principal Investigator for this instrument is Richard Bevilacqua of NRL. The water vapor instrument consists of a cryogenically cooled 22 GHz radiometer and multi-channel filter spectrometer. The TMF facility provides an all-weather, year-round, 24-hour per day operating site with provisions for on-site weather monitoring and archiving, and automated data transfer between TMF and the principal investigators. Daily calibrations and routine maintenance are carried out by JPL personnel 7 days a week. It is proposed that these instruments will eventually be relocated at the NDSC station at Mauna Loa, Hawaii. Since there will also be a JPL lidar at this station, it will be possible to continue the same level of support for the microwave instruments at the new location.

W93-70373 464-14-00
Ames Research Center, Moffett Field, CA.

STRATOSPHERIC PROCESSES AND ATMOSPHERIC CHEMISTRY STUDIES
P. B. Russell 415-604-5404

The objective is to increase knowledge of the stratosphere and its exchange with the troposphere, with particular emphasis on processes related to ozone depletion. The approach is to develop advanced instrumentation for high- and medium-altitude aircraft (e.g., ER-2, DC-8) and balloons; design and develop special platforms, as appropriate; design and fly missions that acquire data on phenomena of interest; and use the data to answer questions of current scientific concern. The measurements encompass stratospheric chemistry, physics, and dynamics. This RTOP includes four field campaigns now in the data analysis stage, one campaign in the planning and execution stage, and possible future campaigns. Names, aircraft, locations, field dates, and goals include: (1) Stratosphere-Troposphere Exchange Project (STEP) (U-2 and ER-2, US and Australia, 1984-87, to improve understanding of processes controlling transport across the tropopause and toward the ozone layer); (2) Airborne Antarctic Ozone Experiment (AAOE) (ER-2 and DC-8, Chile and Antarctica, August and September 1987, to explain the cause of the Antarctic ozone hole); (3) Airborne Arctic Stratospheric Expedition (AAE) (ER-2 and DC-8, Norway and the Arctic, January to February 1989, to study the northern polar stratospheric clouds and ozone depletions); (4) AASE 2 (ER-2 and DC-8, Alaska, Maine, Norway and the Arctic, October 1991 to April 1992, to improve
understanding of heterogeneous radical chemistry and dynamics associated with ozone loss; and (5) AAOE-2 (ER-2 and DC-8, New Zealand, Chile and Antarctica, April to September 1994, to study Antarctic ozone depletion).

**W93-70374** 464-14-20  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**MICROWAVE TEMPERATURE PROFILER**  
B. L. Gary 818-354-3198

The proposed work consists of two parts: (1) analysis of data taken with JPL's Microwave Temperature Profiler (MTP) instruments (MTP/ER2 and MTP/DC8) when they flew on NASA's ER-2 and DC-8 aircraft during the AASE-II (Airborne Arctic Stratospheric Expedition II); and (2) training of a new employee in the "art" of the MTP/ER2 and MTP/DC8 instruments and data analysis. The MTP-derived temperature fields will be used to study atmospheric dynamic phenomena related to polar ozone depletion. The new employee will be trained so that during the following year it will be more feasible to participate in the ASHOM (Airborne Southern Hemisphere Ozone Mission). The MTP instruments are airborne passive microwave radiometers that make scans of 'brightness temperature' versus elevation angle, which are converted to profiles of air temperature versus altitude. The altitude temperature profiles are used to infer which altitudes are cold enough to produce polar stratospheric clouds. The altitudes of isentrope altitude curtain cross-sections. These cross-sections are then studied for the presence of various dynamical meteorological processes, such as 'gravity wave' altitude oscillations of air parcels.

**W93-70375** 464-16-01  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**MULTI-SENSOR BALLOON MEASUREMENTS**  
O. F. Raper 818-354-2435  
(464-12-05; 464-12-06)

Continuing technical, logistical, and operational support of stratospheric balloon flights is provided to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Four modular gondola systems can carry multi-instrument packages consisting of several JPL remote sensing instruments, and instruments from other institutions in the U.S. or abroad, configured for a particular scientific purpose. Data obtained on the altitude profiles for a number of chemically coupled species from one or simultaneous flights in the same air mass is used for instrument intercomparison purposes and for the validation of atmospheric chemical models.

**W93-70376** 464-21-02  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**CHEMICAL KINETICS OF THE STRATOSPHERE**  
L. F. Keyser 818-354-3234

A program is underway to determine rate constants and product yields of atmospheric reactions by laboratory kinetics and photochemical techniques, to develop new experimental methods to detect reactive species under conditions of temperature and pressure occurring in the atmosphere, and to study the physical-chemical properties of atmospheric aerosol surfaces. These studies will be carried out using a discharge-flow resonance fluorescence system interfaced with infrared diode-laser spectrometry and mass spectrometry. Aerosol surfaces will be studied using infrared spectrometry, gas-absorption analysis, and scanning electron microscopy.

**W93-70377** 464-21-05  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**HOMOGENEOUS AND HETEROGENEOUS PROCESSES OF ATMOSPHERIC INTEREST**  
M. T. Leu 818-354-2432

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

**W93-70378** 464-21-06  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**KINETICS OF TROPOSPHERIC AND STRATOSPHERIC REACTIONS**  
S. P. Sander 818-354-2625  
(464-53-01)

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

**W93-70379** 464-22-01  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE**  
W. B. DeMore 818-354-2436

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

**W93-70380** 464-23-00  
**Ames Research Center, Moffett Field, CA.**  
**QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE**  
C. Chackerian, Jr. 415-604-6300

Remote and in situ detection and measurement of stratospheric minor constituent species via spectroscopic techniques are being routinely employed to develop a better understanding of this portion of our atmosphere and man's effect upon it. Proper interpretation of these measurements relies strongly on having the correct molecular parameters. The objective of this work is to obtain laboratory measurements of basic molecular parameters, such as rovibrational line intensities and half-widths, absorption band intensities, vibrational and rotational constants, vibration-rotation interaction constants, and line position measurements including pressure induced shifts, as well as to develop new spectroscopic techniques to detect species in question. These parameters, and their dependence on pressure and temperature, will be determined from spectra obtained by using cooled cells, long path gas cells, high resolution interferometers, and tunable diode laser spectrometers. At Laboratoire d'Infrarouge various experimental techniques and new theoretical approaches are being used to obtain and interpret infrared spectra of free radical molecules. Also, in collaboration with Stanford University, the sensitivity of magnetic circular dichroism will be tested for in situ detection of the OH radical via the A to X transition. A prototype detector for free radicals, based on the technique of infrared magnetic rotation spectroscopy, is being constructed.

**W93-70381** 464-23-08  
**Jet Propulsion Lab., California Inst. of Tech., Pasadena.**  
**INFRARED LABORATORY SPECTROSCOPY IN SUPPORT OF STRATOSPHERIC MEASUREMENTS**  
R. A. Toth 818-354-6660

For the proposed task, high resolution infrared laboratory spectra of stratospheric molecules will be recorded and analyzed to produce line lists of molecular parameters (line frequencies, strengths, widths, and lower state energies). The molecules studied will be those minor and trace species of importance in understanding the Earth's atmosphere. The particular spectral regions to be analyzed (2 to 16 microns) coincide with those used by NASA field experiments that do remote sensing by high resolution spectroscopy (ATMOS, BLISS, Mark IV, UARS, EOS, and the ground-based network). The laboratory spectra will be recorded at spectral resolutions of 0.0028/cm, 0.0056/cm, and
momentum budgets; and (4) the importance of short vertical scale phenomena to lower stratosphere latitudinal transport. The tasks under this RTOP will address these issues by analysis and modeling of high-altitude aircraft measurements taken during a number of recent campaigns, primarily the Stratosphere-Troposphere Exchange Project campaign of 1987, the Airborne Antarctic Ozone Experiment of 1987, the Airborne Arctic Stratosphere Expedition (AASE) of 1989, and AASE 2 of 1992. Measurements include meteorological variables, ozone, nitrogen oxides, water vapor, total water, particle data, carbon monoxide, nitrous oxide, cosmogenic radionucleides, and chlorine and bromine compounds. Auxiliary data (radiosondes, satellite measurements) will also be employed.

Solid Earth Processes

The purpose of this research is to address several long-standing topics in the dynamics and chemistry of the lower stratosphere, including: (1) tropical and midlatitude stratosphere-troposphere exchange; (2) the stratospheric water budget; and (3) transport within the lower stratosphere. Scientific questions about the following topics will be addressed: (1) the respective roles which tropical convection and regional ascent play in the mass input into the tropical stratosphere; (2) implications for the stratospheric water budget; (3) the importance of gravity waves and turbulence to lower stratosphere transport and
The plate margin kinematics and deformation of northwestern South America have been studied at the Jet Propulsion Lab., California Inst. of Tech., Pasadena. Blind thrust and related reverse faulting geometries are a specific focus in addressing the problems of stress and strain accumulation in deformation fields. Continuing research employing these techniques has been successful in gaining insight into the physical processes driving and controlling episodic and steady deformation at plate boundaries. The techniques have been useful for understanding plate tectonic deformation in spatially inhomogeneous domains. This modeling method uses the finite element method to construct time dependent models of constitutive properties and stresses. The task described in the present RTOP addresses the underlying physical processes giving rise to the observed motions. The approach employed in this task uses the finite element method to construct time dependent models of tectonic deformation in spatially inhomogeneous domains. This approach allows the description of realistic configurations of faults and variable material properties that are not amenable to analytic techniques. These modeling methods have proven useful for understanding plate tectonic deformation processes and surface deformation fields. The continuation of this work will be aimed specifically at the problem of stress and strain accumulation in blind thrust and related reverse faulting geometries.

W93-70389 465-12-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODELING OF CONVERGENT PLATE MARGIN DEFORMATION
P. R. Lundgren 818-354-1795
The objectives of this RTOP are as follows: (1) to determine the plate margin kinematics and deformation of northwestern South America and adjacent plates; (2) to assess seismic strain accumulation versus steady slip deformation models with the plate margin kinematics and deformation models for Alaska; and (3) to understand the role of oblique convergence on plate margin deformation in northwestern South America, Sumatra, the Southwest Pacific, and Alaska. The approach of this RTOP will be as follows: (1) to use a joint, weighted least squares inversion of geologic and Central and South America (CASA) GPS baseline data, in a finite element formalism to obtain the velocity field and strain deformation in northwest South America, (2) to compare the Very Long Baseline Interferometry (VLBI) and Global Positioning System (GPS) geodetic measurements for Alaska with kinematic deformation models, and with earthquake strain accumulation models; and (3) to extend application of the inversion method to obliquely convergent subduction zones in Sumatra, New Guinea, and the Southwest Pacific, where space geodetic results exist, to model their deformation, and compare these models with oblique convergence deformation in South America and Alaska.

W93-70390 465-13-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS OF NORTH AMERICAN-PACIFIC SHEAR
E. R. Ivins 818-354-4785
The objective of this RTOP will be to constrain deformation models along the western boundary of North America by modeling analysis of fault structure, seismicity patterns, sub-crustal structure, and geodetic data. There are five parts to the proposed work of this RTOP. The first part is the model treatment of the crustal structure beneath the western Transverse Ranges. Included are complexities of all fault senses of motion (dextral, sinistral, reverse, etc.). The second part is the application of the analytic method of aseismic creeping motion to a buried thrust-strike slip fault south of the Big Pine fault and north of the Santa Cruz Island fault to determine the upper bound on compressional strain accommodation. The third part is to apply semi-analytical analysis to three-dimensional ductile flow beneath the North American Pacific boundary. The fourth part is to use GPS observations and Global Positioning System (GPS) data to constrain regional block rotations. The fifth part is to use assumed rates of motion at depth and develop self-consistent stress transfer models that match known crustal deformation rates.

W93-70391 465-13-05
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS STRAIN MONITORING IN THE NEW MADRID SEISMIC ZONE
D. M. Tralli 818-354-1835
Large earthquakes in the New Madrid seismic zone (Missouri, Arkansas, Illinois, Kentucky, and 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 were inferred using isoseismal data. However, the locations and mechanisms of more recent earthquakes were used to delineate the seismic zone and to analyze the faulting in the larger post-1960 events. Earthquake recurrence and probability estimates were derived from historic magnitude-recurrence data. The absence of recent large earthquakes poses difficulties: mechanisms are available only for events with m(sub b) less than or equal to 5.0, and the recurrence estimates for events with m(sub b) greater than or equal to 5.4 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 have initiated a collaborative research program with Northwestern University, the University of Missouri, and the University of South Carolina, using Global Positioning System (GPS) geodesy to quantify the rate and distribution of strain accumulation in the New Madrid seismic zone. We have established and measured 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 bi-annual measurements to determine baseline changes and thus provide quantitative constraints on the regional tectonics, fault zone mechanics, and earthquake recurrence, and for understanding GPS errors such as tropospheric path delays and azimuthal asymmetry, and also assessing regional strain constraints with ROGUE GPS receivers in network.

W93-70392 465-13-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE DEFORMATION IN THE MOJAVE DESERT AND WALKER LANE: A GLOBAL POSITIONING SYSTEM EXPERIMENT
M. M. Miller 818-354-8620
The objectives of this RTOP is to carry out Global Positioning System (GPS) experiments that will monitor fault motions both within the Mojave Desert and between the Mojave Desert and adjacent areas. These studies will: (1) characterize the role of Mojave faulting in accommodating modern Pacific-North American plate motions; (2) establish new constraints on the relation between tectonism the Mojave Desert and adjacent structural domains; and (3) provide local strain rates that will aid in defining local displacements around NASA's Crustal Dynamics Project MOJAVE and Owens Valley Radio Observatory (OVRO) base stations. Site location, monumentation, and related field work for the regional network and one tectonic footprint network at the MOJAVE base station was conducted in 1991. Both networks were occupied in May 1991. Additional sites and tectonic footprint network will be added during the remainder of FY-92. In addition, data reduction for the 1991 experiment is currently underway. Reoccupation of the regional network and the first occupations of additional local networks will occur on a biannual basis. Data reduction will occur mostly in the alternate years. Ongoing field studies will focus on characterizing localized deformation detected by Global Positioning System experiments.

W93-70393 465-13-08
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PARKFIELD GPS EXPERIMENT
K. Hurst 818-354-6637
The objectives of this RTOP are as follows: (1) to better determine the slip distribution on the northwestern part of the Parkfield segment of the San Andreas fault before, during, and after the earthquake which is predicted to occur there in the next few years; (2) to prove the accuracy of the Rapid Static Survey.
will be used to study the slow divergences in the observed Earth changes in baseline length. Publicly available Earth orientation results necessary for a complete analysis of network deformation. Simultaneously inverting VLBI and GPS data will eliminate the practice of assuming 'fiducial' locations are absolutely known when GPS data are analyzed.

W93-70394 465-14-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

GLOBAL TECTONIC MOTIONS
R. S. Gross 818-354-4010

The proposed research is intended to continue the study of present day plate motions using Earth orientation measurements, and the related production of Earth orientation series which account for tectonic motions of the participating geodetic observatories. This will be accomplished by the analysis of publicly available Earth orientation data, and the re-reduction of Interferometer Spectrometer (IRIS), POLARIS, and Crustal Dynamics Project Mark 3 Very Long Base Interferometry (VLBI) data at JPL using JPL software. It should be noted that the inherent accuracy of VLBI baseline orientation determinations can be equal to or better than the length estimates from the same baselines. The study of tectonic motions through orientation measurements will both complement the more traditional study of length changes and serve as an important source of new information, without requiring the acquisition of any additional data. The first task will involve the re-reduction of VLBI/POLARIS and Crustal Dynamics Project Mark 3 VLBI data with an independent JPL software package providing both the length and orientation determinations. The length and orientation of each baseline in the network will be estimated each time it is observed to provide the detailed geodetic results necessary for a complete analysis of network deformation. This will produce determinations of the velocity of relative motions between Europe and America with formal errors of 1 centimeter/year or smaller from both orientation and length data and will greatly increase the confidence in rate estimates from changes in baseline length. Publicly available Earth orientation measurements (Satellite Laser Ranging (SLR), Lunar Laser Ranging, and VLBI from other sources - NASA Crustal Dynamics Project and the Deep Space Network) together with baseline orientation results from the above re-reduction of the IRIS/POLARIS and Crustal Dynamics Project Mark 3 VLBI data, will be used to study the slow divergences in the observed Earth orientation caused by plate motions. In this manner, tectonic motion estimates with formal errors of 1 to 2 centimeters/year or smaller from locations on the North American, European, and Australian plates will be produced. The resulting drift rate estimates will be compared with geological plate motion models and with other geodetic motion estimates.

W93-70395 465-14-07
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

KINEMATIC MODELS COMBINING VLBI, GPS, AND TRILATERATION DATA AND PLATE CONSTRAINTS
D. F. Argus 818-354-7514

We aim to combine geodetic measurements from Very Long Baseline Interferometry (VLBI), the Global Positioning System (GPS), and Satellite Laser Ranging (SLR), and trilateration and use the geometric rigor of rigidity in the plate tectonic model to construct kinematic models of crustal deformation. We aim also to apply these models to outstanding tectonic problems, focusing on the relation between motions of plates, deformation of crust lying adjacent to plates, and geologic phenomena like faults, earthquakes, and mountains. First, rates of change of components of vectors observed with VLBI, GPS, SLR, and trilateration will be inverted; velocities of plates and velocities relative to plates of points in deformation belts will be simultaneously estimated. Estimating velocities of points in deformation belts relative to plates will eliminate ambiguities about reference frame, will result in the automatic application of plate requirements, and will allow deformation to be interpreted in frameworks fixed to plates. Second, vector components (or cartesian coordinates) of sites observed with the four geodetic techniques will be inverted; velocities of plates, velocities relative to plates of points in deformation belts, displacements during earthquakes, and velocity gradient tensors of deformation belts will be simultaneously determined. Simultaneously inverting VLBI and GPS data will eliminate the practice of assuming 'fiducial' locations are absolutely known when GPS data are analyzed.
at existing VLBI facilities of geophysical interest, or established geodetic stability, and with a wide distribution over the U.S. New sites may include Los Alamos, N. Liberty, Ft. Davis, St. Croix, Brewster, Mauna Kea, Hancock, and Kitt Peak. The second part is to retrieve data from DCSE operations, and perform analysis of network GPS data. VLBI data will be analyzed by collaborators at Goddard Space Flight Center. The third part is to perform GPS/VLBI solution intercomparisons and error analyses, assess accuracy, adjust models as appropriate, evaluate site-tie errors, and annually publish fiducial coordinates and site velocities.

W93-70398 465-15-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THEORY OF GEODETIC TRANSFORMATIONS
J. G. Williams 818-354-6466

Several of the mathematical models which govern the transformations between celestial and terrestrial coordinates were developed more than a decade ago. These transformations are used in the reduction of data by all techniques (interferometric or range, laser or radio). The improvements in observational accuracy and data span require the highest accuracy in the models. The assumptions and approximations which these models depend on should be re-evaluated and the models should be improved where needed. Two subjects were picked for initial study and a third has been added. First, the equation of equinoxes has been developed to second order in order to replace the first-order expression. The dynamical evaluation is done, however, the geometrical interpretation deserves further work. Second, the adopted expressions for precession and obliquity changes with time do not take into account that the average lunar torque is not quite aligned with the average solar torque. This correction is important (estimate 0.2 mas/yr) and should be made. Third, the tidally-driven Universal Time (UTI) variations have been computed from analytical expansions in the past, but they can also be done by numerical Fourier analysis.

W93-70399 465-16-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

UPPER MANTLE SEISMIC P AND S WAVE STUDY
D. M. Tralli 818-354-1835

An investigation of the elastic structure of the Earth's upper mantle is sought using global seismic travel-time data (compressional and shear). Global seismic travel-times are tectonically regionalized to estimate velocity functions. Laterally-varying P and S wave velocity inversion results are, in turn, inverted jointly to estimate lateral variations in elastic properties, seismic parameter, density, and Poisson ratio. The results will be used to constrain the interpretation of geoid anomalies, and response of the upper mantle to continental loading. The chemical, phase, and thermal properties of the upper mantle will be imaged, with error bounds, to constrain models of plate interaction and convection. A quadratic programming joint inversion of laterally-varying seismic P and S wave velocities to obtain estimates of elastic parameters with corresponding error bounds, ensuring zero mean anomalies which are consistent with the results of mean Earth models was approached. The results of the study will then be combined with satellite gravity data, and geodetic measurements of plate deformation and uplift, to investigate any correlations with tomographic zones of varying thermal and compositional structure.

W93-70400 465-17-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

GEOPOTENTIAL TEMPORAL VARIATIONS
J. O. Dickey 818-354-3235

The fundamental objectives of this study are to: (1) recover the effects of dynamical Earth processes upon the Earth's geopotential, and interpret these results to gain insight into the Earth's internal structure and processes that can induce changes in the geopotential; and (2) obtain improved estimates for the amplitudes and phases of the tidal terms, and interpret these results to gain insight into the Earth's anelasticity and aspherical structure. The approach includes the following: (1) modification of a version of GEODYN to obtain temporally varying Stokes coefficients, and exploration of various techniques to accomplish this, such as explicitaly obtaining the time-dependent Stokes coefficients, or modeling the effects of the geophysical process on the gravitational field and using GEODYN to search for this modeled effect; (2) use of analytical and numerical models for a variety of geophysical processes in order to both compute the expected effect of these processes upon the geopotential and to interpret the observed temporally varying geopotential results; and (3) the search for correlations between changes in the gravitational field coefficients and changes in the Earth rotation parameters. Any such correlations found will lend greater credence to the time varying geopotential results.

W93-70401 465-17-04
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LATERAL VARIATIONS IN SOLID TIDES
E. R. Ivins 818-354-4785

We shall develop models of solid tidal deformation which include the effects of lateral variation in mantle density, rigidity, and compressibility. Complex tidal models have been developed that are to be compared with available Lagoos 1 and 2 ranging station data and other data. The comparison may produce a new constraint on scaling relations between the elastic constants and seismicity determined data on shear wave and compressional wave velocity anomalies. Low frequency, relative to those of seismic free oscillations, could imply that thermally controlled dislocation mechanisms control a viscous component of the deformation. These effects will be incorporated into the modeling effort. We intend to provide maps from which local station corrections to tidal Love numbers can be obtained. Corrections to earth rotation and ocean tidal loading shall also be determined.

W93-70402 465-27-02
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SHORT-PERIOD TROPOSPHERIC NOISE IN CONTINUOUS GPS MEASUREMENTS
D. M. Tralli 818-354-1835

An investigation of the level of short-period tropospheric path delay noise in continuous Global Positioning System (GPS) geodetic measurements is undertaken. A GPS geodetic network yielding measurements with high temporal and spatial resolution can be used as a strain instrument for monitoring crustal deformation. While smaller strain rates associated with regional tectonic processes can be observed by epoch geodetic measurements, problems in fault zone behavior (such as the depth extent of creep), the relationship between creep and rupture, and the distribution of slip on a fault, suggest that continuous monitoring is desirable given the short periods over which deformation signals may be defined and otherwise aliased. These different geodetic sampling intervals are subject to distinct error sources. Therefore, identifying those GPS measurement errors which may obscure short-term deformation signals is important, as is achieving high resolution in order to avoid aliasing. In addition to short-period tropospheric path delay fluctuations, the amplification of potential GPS signal multipath effects in local networks and the contribution to the short-period noise spectrum also must be considered. Temporal power spectral density (PSD) models of GPS measurement noise will be determined using data from the Permanent GPS Geodetic Array (PGGA). The crossover frequency at which GPS measurement noise is less than that in high-quality strainmeter measurements will be determined. Different frequency crossovers and smaller relative noise pass bands will be identified, depending on the shapes of the noise PSD's which are determined by the tradeoff between geodetic sampling interval, strain estimate variance, and the level of correlated short-period tropospheric path delay noise. The short-period effects of GPS signal multipath, particularly its amplification in processing dual-band data over local distances, will also be modeled as a further noise contribution which may obscure the interpretation of tropospheric path delays and strain measurements.
This RTOP is to provide support services at the Goldstone Deep Space Communications Complex (DSCC) for the Goddard Space Flight Center (GSFC) office of the NASA Dynamics of the Solid Earth (DOSE) program. The Mojave Base Station (MBS) has been maintained as a part of the Crustal Dynamics Project (CDP) headquartered at GSFC. The CDP terminated, as scheduled, at the end of calendar 1991. Operation of MBS is being phased out in 1992 as the station prepares for closure. Operation will cease altogether and permanently before the start of FY-93. There will be no staff stationed at this facility in the future; all instruments and furnishings will be removed. However, a minimal level of maintenance must be provided for the protection of the antenna and the building which are NASA property. In addition, the Very Long Baseline Interferometry (VLBI) group of the GSFC DOSE program requests support at a level not to exceed 2 days per month for VLBI experiments at one of the operational Goldstone antennas, probably DSS 13. This function includes the designation of an individual to act as the point-of-contact for the GSFC DOSE office at the Goldstone DSCC. Finally, there is a Doppler Orbitography and Radiopositioning Integrated Satellite (DORIS) beacon at the Mojave Base Station site which will continue to operate and which will support the TOPEX/POSEIDON mission. This is an autonomous instrument, requiring maintenance only on an as-needed basis.

W93-70404
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED MAGNETOMETER
E. J. Smith 818-354-2248
The objectives of this RTOP are to: (1) operate the helium magnetometer in a scalar mode and demonstrate that it can meet the requirements of future investigations to study secular changes in planetary magnetic fields and to detect crustal magnetic anomalies; (2) evaluate the sensitivity and accuracy of the magnetometer when operated in the vector mode in strong planetary (Earth-like) magnetic fields and to investigate alternative modes of operation to make vector measurements; (3) optically pump helium using an IR laser rather than a lamp excited by an electrodeless discharge and to evaluate the consequences for the magnetometer performance; (4) investigate the possible use of a solid state semiconductor laser and fiber optics in a space flight magnetometer to transmit the pumping radiation between the electronics and sensor; (5) evaluate the magnetometer performance in a hybrid mode in which it alternates (rapidly) between scalar and vector operation; and (6) evaluate the He nuclear precession magnetometer for possible use in space.

W93-70405
Goddard Space Flight Center, Greenbelt, MD.
GEOLOGICAL INTERPRETATION OF MAGSAT ANOMALY DATA
Patrick T. Taylor 301-286-5412
The objective of this RTOP is to determine the nature, source depth and petrology of the source of the long and intermediate wavelength magnetic anomalies observed at satellite altitude. All relevant geology and geophysical data bases will be used as an aid in this task. Specific areas of study include the mid-continent of the United States and the shield area of the Arabian Peninsula. The project will continue to develop and refine new methods and techniques for reducing and representing Magsat orbital profiles. This includes new methods for noise reduction, for gridding and plotting data, and for analytical interpretation techniques. These data will be combined with the latest results from the analysis of the magnetic properties of lower crust upper mantle petrologic studies.

W93-70406
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARISTOTELES GPS RECEIVER DEVELOPMENT
E. S. Davis 818-354-8644
The objectives were to develop a set of requirements, select a conceptual design, and layout the program for acquiring the flight equipment needed to support the scientific objectives of the ARISTOTELES mission. The approach follows our proposal. The Global Positioning System (GPS) Tracking System for ARISTOTELES was submitted to NASA on 10 July 1991 and updated on 18 November 1991 to reflect the ESA decision to extend the project definition phase for one year. The Jet Propulsion Laboratory (JPL) has been developing GPS receivers for precision ground applications for the last decade. The latest in the series of ground receivers developed at JPL are the Rogue and TurboRogue. For the Topographic Ocean Experiment (TOPEX)/POSEIDON mission, JPL contracted with Motorola to develop a flight GPS receiver with similar functional characteristics to the ground receivers and with easily achievable performance specifications. Motorola calls this receiver the 'Monarch'. Two flight qualified Monarchs were delivered to the TOPEX/POSEIDON satellite in the spring of 1991. They will operate as a redundant pair. The TurboRogue was also the basis for the conceptual design of the GPS Geoscience Instrument for the Earth Observing System (EOS). At this point, two salient options exist for developing the flight GPS receiver needed for ARISTOTELES: (1) upgrade the performance of the Monarch, adding Application Specific (AS) capability and correcting design deficiencies that stem from errors in the details of the Application Specific Integrated Circuit (ASIC) logic; and (2) identify a flight qualified microprocessor that allows us to adopt the TurboRogue signal processing architecture, it's ASIC design, and software. For each option, the cost for an acceptable level of risk will be estimated, and the performance characterized. From this, a decision on the design concept will be made and the process of acquiring the flight equipment initiated.
the main factor affecting scheduling in Egypt, one or two extended expeditions will be required to make measurements at that site.

W93-70408
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF REMOTE SENSING IMAGERY TO NEOTECTONIC PROBLEMS IN THE BAJA CALIFORNIA PENINSULA
M. Miller 818-354-4977
The objectives of this RTOP are as follows: (1) to understand the modern and recent kinematic framework of tectonic evolution of the western North American plate margin, specifically at the latitude of Baja California; (2) to resolve questions concerning the transfer of slip from spreading ridge-transform systems in the southern Gulf of California to offshore fault systems in southern California; (3) to generate a data base that elucidates the evolution of the Gulf of California and related deformation over the last 5 million years; and (4) to provide constraints for NASA supported geodetic studies in Baja California by identification and study of active faults. The approaches to accomplish this RTOP are as follows: (1) purchase, process, and interpret LANDSAT Thematic Mapper images for the Baja California Peninsula; (2) pinpoint areas of neotectonic activity and supplement the TM data base with SPOT data; (3) carry out geologic mapping and related field studies in areas defined by 1 and 2; and (4) interpret results in the context of the regional tectonics of western North America.

W93-70409
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTISPECTRAL ANALYSIS OF THE STRATIGRAPHIC/STRUCTURAL RECORD, SOUTHWEST MEXICO
H. R. Lang 818-354-3440
The primary objectives are to: (1) refine the geological understanding of the formation and evolution of the southern margin of the North American plate in the Guerrero-Morelos basin region of Southwest Mexico; (2) evaluate the utility of remote sensing conducted at visible-thermal infrared wavelengths combined with topographic data for mapping strata, defining stratigraphic sequences and modeling facies, and delineating geologic structures and inferring tectonic regimes; (3) integrate lithostratigraphic and structural information from remotely sensed and topographic data with that obtained from conventional field geological and geophysical data using the IGIS workstation; and (4) use results to test existing models and develop new models of Mesozoic terrane accretion/plate interaction along the southern edge of the North American plate. The approach is to acquire, coregister, and analyze remote sensing data from satellite and aircraft systems and conventional geological and geophysical data to: (1) define stratigraphic and basement units, map facies and determine their physical, chronological, and mineralogical attributes in order to infer environments of deposition and paleogeography; and (2) map structure/measure kinematic indicators to infer tectonic evolution. A final product will be an east-west crustal traverse through the region of study representing a testable model for lithospheric formation and evolution of the southern edge of the North American plate and its interaction with the Pacific and Caribbean plates in the Southwest Mexico study area. Field and laboratory studies will be performed to support interpretations.

W93-70410
Langley Research Center, Hampton, VA.
SATELLITE OBSERVATIONS OF VOLCANIC AEROSOLS
M. P. McCormick 804-884-2669
This RTOP results from the proposal, 'Satellite and Ladar Measurements of Stratospheric Volcanic Aerosols and Applications to Climate Change', (NASA #1461-VCIP-014), a study which was selected for funding. The objective is to use lidars and the Stratospheric Aerosol Measurement (SAM) II/Stratospheric Aerosol and Gas Experiment (SAGE) (SAM II/SAGE) satellite experiments to provide global data pertinent to the role stratospheric aerosols of volcanic origin play in climate change. Langley's expanded long term lidar and satellite stratospheric aerosol data base along with extensive aircraft and field mission validation data will be used to study the impact of volcanic eruptions on climate. Investigations of aerosol cloud height and spatial distribution, the global dispersion of aerosol, aerosol mass, size distribution, surface area and residence time resulting in global maps and time series plots will be produced and reported to the Volcano-Climate Interaction Program (VCIP) Team.

W93-70411
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF ACTIVE AND RECENTLY ACTIVE VOLCANIC FEATURES
D. C. Pien 818-354-6299
Under this RTOP we request support to continue acquisition and analyses of multispectral data on active and recently emplaced volcanic features and related aerosol, gas, and particulate emissions across a variety of wavelengths from UV through short and long wavelength thermal infrared, and radar (e.g., UVIS, AVIRIS, NS001, TMS, TM, TMS, SPOT, Zeiss, SAR, and Inframetrics 525). We are investigating the relationship between remotely acquired data and the spectral/physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). We are continuing comprehensive analyses and comparisons between the Hawaiian (Mauna Loa-Kilauea), Italian (Etna), and Kamchatkan (Toibachei) basaltic shields, including analyses of thermal data from active lava flows, statistical distributions of flow ages, multispectral mapping, and theoretical process models of surface and atmospheric components. We will continue spectra vs. process analyses of explosive volcanoes, such as Vesuvius and St. Helens, as well as volcanoes on the Kamchatka Peninsula (Ksudach, Bezymyanny) and Alaska (Katmai). In addition, we are beginning a unique 10-year retrospective time-series analyses of Landsat Thematic Mapper (TM) data of Etna, including comparisons between remotely perceived activity and geophysical data. Finally, we are continuing recent retrospective and prospective work on the impact of near-polar eruptions on short term weather/climate and ozone abundance at high latitudes. We are drawing on data and techniques already acquired and proven by the JPL Geology Group and on ongoing work and accomplishments under this program in theoretical and applied volcanology. We are applying a variety of remote sensing techniques from satellites and aircraft to address basic volcanological problems (e.g., thermal budgets of active lava flows), and are extending insights toward global habitability and societal risk concerns. In addition, under this RTOP, support is requested for continuing participation, planning and execution of a cooperative volcanology and remote sensing program with the Russian Academy of Sciences. Funds are also requested here for the development of the proposed Orbiting Volcanological Observatory.

W93-70412
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EVOLUTION OF VOLCANIC TERRAINS
M. J. Abrams 818-354-1799
The long range goals of this study are to: (1) develop weathering histories of lava flows along strong remnant gradients to infer climatic influences; (2) study and date cinder cones and maars to determine effects of climate on volcanic landforms, and correlate with glacial chronology; (3) determine the thermal characteristics of active volcanic phenomena, such as lava tubes, domes, and lava lakes to assess thermal budgets and understand dynamics of lava emplacement; and (4) measure SO2 emissions from Mt. Etna using thermal images and the LOWTRAN7 model to determine tropospheric contributions of this volcano to the SO2 budget. Our approach is to combine modeling, processing and interpretation of aircraft and satellite image data, field measurements and mapping, and laboratory studies to address the objectives. In Hawaii, we will combine Digital Elevation Model (DEM) data with aircraft data to determine the effects of varying climate on single flows, using elevation controlled rainfall gradients to examine weathering effects. We will use TMS and NS-001 data to study the thermal dynamics of lava tube systems to estimate
A large volcanic eruption will be studied and accuracies and detection limits will be determined for measurements of volcanic gases by remote sensing instruments. High resolution laboratory spectra will be recorded in the 1.2 to 12 micron region using Fourier transform absorption spectrometers to provide reference data. Previously published studies on absorption features for all of the important volcanic gases over the 1 to 12 micron wavelength range will be reviewed and validated using the new spectra, and new predictions will be done to form the supplemental molecular database of volcanic species. Portions of the laboratory spectra will be measured as needed for at least two of the four important sulfur species. In particular, detailed measurements and quantum mechanical analyses will be performed to derive line intensities and line shape parameters of prominent OCS and CO2 bands. With the absorption line database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied. Radiative transfer calculations will be used to determine detection limits and accuracies for measurements of each of the volcanic gases by instruments on Earth Observing System (EOS) and Upper Atmosphere Research Satellite (UARS) platforms.

**W93-70413**

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

**VALIDATION OF VOLCANIC PLUME MODELS WITH REMOTE SENSING**

S. M. Baloga 202-479-2609

The objective of this study is to validate theoretical models used to describe buoyant volcanic plumes. This will be accomplished by first critically examining the physics in contemporary plume models, secondly by analyzing them for quantities that must be measured, and finally by conducting these measurements using available ground based and airborne remote sensing instruments. We will determine under what atmospheric conditions and initial parameters the models can be used. In this way, we will improve the understanding of volcanic ash and gas injection into the upper atmosphere. An additional goal of this study is to demonstrate the usefulness of simultaneous visible, UV, and IR measurements of buoyant plumes and to develop measurement methodologies that can be used with instruments on large satellite platforms such as the Earth Observing System (EOS). The first phase of this study has resulted in an internally consistent model of buoyant plume dynamics based on the Morton system of equations for volume, momentum, density and temperature. The second phase has involved a thorough study of the effects of variations in several plume parameters. Consequently, several variables (temperature, density, condensation rate, particle fallout rate) have been identified that can critically effect calculations. The next phase of this study will involve ground based remote sensing measurements of some of these variables in order to determine the adequacy of the physical description. Finally, the regimes for which Morton type models are valid will be characterized according to initial vent conditions and standard fluid dynamics parameters such as the Reynolds and Richardson numbers.

**W93-70414**

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

**MEASUREMENT OF VOLCANIC GASES**

J. A. Crisp 818-354-9036

Volcanic gas emissions can have an important impact on atmospheric chemistry and greenhouse warming. Efforts to monitor these gases and to assess their global impact by remote sensing are seriously hampered by the lack of a complete and accurate database of molecular line parameters for all volcanic sulfur species. The absorption line parameters required are the positions, intensities, transition lower state energies, and line shapes. We are compiling a supplemental database that includes the important volcanic gases not available in the 1991 Air Force Geophysics Laboratory High Resolution Transmission (HITRAN) or GEISA compilations. Existing published results will be converted to the HITRAN database format and new laboratory studies for important sulfur carrying species will be undertaken. The resulting supplemental database will be described in a technical report. With HITRAN and the new supplemental database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied and accuracies and detection limits will be determined for measurements of volcanic gases by remote sensing instruments. High resolution laboratory spectra will be recorded in the 1.2 to 12 micron region using Fourier transform absorption spectrometers to provide reference data.

**W93-70415**

Ames Research Center, Moffett Field, CA.

**VOLCANIC CLOUD DISPERSION, CHEMISTRY AND MICROPHYSICS: AN ANALYSIS OF THE EL CHICHON ERUPTION**

R. E. Young 415-604-5521

The objective of this RTOP is to simulate the dispersion and climate effects in the stratosphere of the El Chichon and Mt. Pinatubo volcanic aerosol clouds. An extensive data set obtained from ground based, aircraft, and satellite measurements exists for the years immediately following each eruption. The results from the model simulations will be compared to the data, with the intent of developing a better understanding of stratospheric transport processes and climatic effects of large aerosol loadings in the stratosphere. The approach is to use a three-dimensional stratospheric circulation model coupled to a three-dimensional aerosol/transport model to simulate the volcanic aerosol clouds. The circulation model calculates stratospheric wind and temperature fields, which are then input to the aerosol model to conduct the transport and compute aerosol microphysical processes such as coagulation and sedimentation. The coupled models have the capability to investigate chemical, microphysical, and global transport processes in the stratosphere important for simulating the behavior of large aerosol injections into the stratosphere.

**W93-70416**

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

**CARBON MASS BALANCE DURING SOIL EVOLUTION ALONG CLIMATE GRADIENTS**

O. A. Chadwick 818-354-6229

The objective of this research is to develop datasets that will allow prediction of the response of soil processes and their resulting properties to climate change. Most soil processes leave their imprint on the geologic substrate over relatively long periods of time that do not allow in situ measurements of the actual processes. The practical approach to understanding the role of climate change on pedologic processes is to develop time-climate matrices following the chrono-climosequence concepts to quantify soil properties and infer the time/climate processes that underlie the changes in properties. The approach is to focus on elemental and mineralogical gains and losses which will emphasize the essential connections among the pedological, hydrochemical, geological, and atmospheric environments. Chemical elements such as carbon, nitrogen, phosphorus, calcium, silicon, and aluminum will be used as tracers in a mass balance analysis that provides functional relationships among soil chemical composition, bulk density, and volume change in relation to parent material. These analytical functions are based on the principle of conservation of mass and include terms that quantify the cumulative deformation during soil development and the mass flux into/out of the soil and between horizons. In addition to documenting deformation and mass flux during pedogenesis at different times during the evolution of soils developing under different climates, we will quantify the elemental distribution among: (1) mineral, noncrystalline inorganic, and organic phases, and (2) particle-size...
separates. The purpose of this effort will be to document the rates at which primary minerals are weathered and the types of secondary mineral synthesis that occur under different climate regimes. The primary geographic/geomorphic areas covered by this research will be (1) marine terraces along the Pacific coast of Oregon, California, Mexico and New Zealand, (2) lava flows on the Island of Hawaii, (3) glacial deposits and fluvial terraces in the Basin and Range and Rocky Mountains, and (4) Queensland, NE, Australia. Each of these sites provides important climate gradients, parent material uniformity, and geographic diversity. The level of emphasis for each area will be determined during preliminary field investigations.

W93-70417
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE INTERFEROMETRIC TOPOGRAPHY
H. A. Zebker 818-354-8780
(462-74-01)

The objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objective here is to develop such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer mode on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar RF switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce less than 2 m height accuracy DEM's with precisely co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in a manner that will allow it to be operated in a routine manner, should NASA wish to fund it as part of the AIRSAR system. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.

W93-70420
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS
J. J. vanZyl 818-354-1365
(462-75-62; 665-81-08)

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parameterized surface physical characteristics. In addition, this work serves to develop engineering methods that can be and are used to fabricate spacecraft SAR systems. AIRSAR is a three-frequency (P-, L- and C-band), fully polarimetric SAR that acquires all twelve data channels simultaneously, resulting in co-registered images at all frequencies. In FY-93, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and JPL. Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SAR'S. The plan is to reduce the data from up to 600 scenes to three frequency imagery, each with four polarizations (12 images). System evaluation will be carried out to assess the validity of the data. We shall calibrate the AIRSAR data using the results from calibration flights over Rosamond Dry Lake in California. The development of an upgraded ground data processing facility will be completed in FY-92 under separate funding; the new system will allow improvements to be made in data quality and increase the processing throughput.
The objectives are to: (1) develop new multi-channel, multi-instrument cloud analysis methods, including new cloud detection schemes and more sophisticated radiative transfer models; and (2) develop analysis methods to infer cloud-radiative feedbacks from the International Satellite Cloud Climatology Project (ISCCP) data. The approaches are to compare ISCCP results to observations from a full complement of instruments on the NOAA polar orbiters, including sounders, and to measurements by other instruments, such as microwave radiometers; develop methodologies to infer cloud-radiative feedbacks from ISCCP data; and compare results to products produced by ERBE, the Surface Radiation Budget Project, and climate model simulations.

W93-70425
Goddard Inst. for Space Studies, New York, NY.
AN INTEGRATED STUDY OF SURFACE PROPERTY VARIATIONS
William B. Rossow 212-678-5567

The objective of this RTOP is to develop a combined analysis procedure, using both satellite and surface observations, to obtain accurate estimates of global surface albedo and temperatures. The approach is to: (1) combine the International Satellite Cloud Climatology Project (ISCCP) results with other measurements of the surface at other wavelengths and from conventional surface measurements to determine a more accurate representation of these key surface variables over the whole globe for two years, one 'normal' year and one 'perturbed' year (i.e., El Nino); and (2) extend ISCCP calibrations to other spectral bands.

W93-70426
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF AIR-SEA FLUXES
W. T. Liu 818-354-2594 (578-12-18)

The objectives are to study, using spaceborne sensors, the interactive processes of ocean-atmosphere exchanges in momentum, heat, and moisture and their effects on ocean thermodynamics and dynamics. Feasibility studies on computing latent heat flux using Seasat/Scanning Multichannel Microwave Radiometer (SMMR) data were successfully performed. A global relation between precipitable water and surface humidity was derived. Adaptation of bulk parameterization models to satellite data in the tropical oceans was examined. Four years of Nimbus/SMMR data were evaluated and the latent heat fluxes computed in the tropical Pacific, the seasonal cycles and the anomalies during the 1982-83 El Nino Southern Oscillation (ENSO) episode were studied. Combining with surface insolation, the net heat flux fields were constructed as part of the Tropical Ocean Global Atmosphere (TOGA) Heat Exchange Project. The results were used to study thermal forcing of the sea surface temperature changes in the eastern tropical Pacific. In light of our results, the conventional approximations used in computing latent heat flux in ocean numerical models were evaluated. High frequency variability of humidity distribution in the atmosphere was studied to understand the physical basis and limitation of our technique for estimating surface level humidity and humidity profiles from satellite data. Wind forcing of deep current during the OCEAN STORM experiment was studied. Extension of our heat flux technique to use Special Sensor Microwave Imager (SSMI), Advanced Very High Resolution Radiometer (AVHRR) and International Satellite Cloud Climatology Project (ISCCP) data on global tropical ocean is being pursued. Evaporation as an ocean thermostat and precipitable water as a greenhouse gas will be studied. A state-of-the-art eddy resolving ocean general circulation model is being implemented to study the ocean's responses to surface forcings.

W93-70427
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METEOROLOGICAL PARAMETERS EXTRACTION
M. T. Chahine 818-354-6057 (578-12-21)

The overall objective of the proposed research is the
W93-70428
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ATMOSPHERIC PARAMETER MAPPING
K. J. Hussey 818-354-4016
(578-12-20)

The primary objective of the Atmospheric Parameter Mapping (APM) task for FY-93 is to initiate a multi-year archiving and visualization task, beginning with the development and delivery of a prototype compact disc (CD) browse product designed to greatly facilitate the analysis, acquisition, visualization, and exchange of satellite imagery from such platforms as NOAA High Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) and Atmospheric Infrared Sounder (AIRS). The secondary, related objective for FY-93 is to develop tools and methodologies which serve to streamline and accelerate the process of utilizing and preparing satellite data, such as those found on the proposed CD browse product, for high-quality visualizations such as parameter maps and time-series imagery. In conjunction with atmospheric scientists at JPL, the proposed approach to completing the primary objective of the APM task will be as follows. The browse product will incorporate a user-friendly Macintosh-based application interface designed to allow the user to visually inspect the data files stored on a browse product CD. All files will be in the Hierarchical Data Format (HDF) developed by the National Center for Supercomputing Applications (NCSA). Data descriptors such as file name, parameter type, and data resolution will be stored in every file. Each browse product CD will contain HDF-based satellite data, the Macintosh interface application, and non-proprietary NCSA analysis and display applications designed for HDF data usage. Through the use of the proposed application interface, an atmospheric scientist will be able to examine the contents of a browse product CD, obtain descriptive information about any HDF file, use data filters to transform or convert HDF data to a different format type, and launch NCSA applications. The approach to completing the secondary objective will be built upon existing image processing techniques currently utilized in the production of high-quality visualizations. The current procedures undertaken to prepare raw atmospheric satellite data for high-end visualization will be reviewed, revised, and expanded upon where necessary in order to provide a solid bridge between raw, archived data, and high-quality visualizations suitable for formal presentations and publications. Once acceptable methodologies have been established, improved techniques for processing the archived data will be constructed and incorporated into user-friendly, easily expandable modular procedures designed for use by atmospheric scientists.

W93-70429
578-12-59
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OUTGOING SPECTRAL RADIANCE: A CLIMATE DIAGNOSTIC
R. D. Haskins 818-354-5893

The objective of this RTOP is an evaluation of the use of spectral radiances as diagnostics of physical climate processes; a concurrent investigation will be made of errors in forward calculations of radiances. This collaborative effort between Atmospheric and Environmental Sciences, Inc. and the Jet Propulsion Laboratory is addressing the following research tasks: (1) the response of the earth’s outgoing spectral radiance to changes in physical processes as revealed in simple climate models; (2) the development of a methodology for utilizing satellite radiance measurements for the present purposes by studying the Infrared Interferometer Spectrometer (IRIS-D) data from the NIMBUS 4 Satellite; (3) the validation of our ability to model high resolution spectral radiance data (approximately 1/cm) using High Resolution Interferometer Sounder (HIS) spectral radiance observations; and (4) the implementation of indicated improvements in the forward radiative transfer model. The results developed here will be evaluated in the context of application to Earth Observing System (EOS), particularly with respect to the Atmospheric Infrared Sounder (AIRS) Experiment.

W93-70430
578-21-12
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 use satellite altimetry for describing, understanding (and predicting) oceanic circulation and its variations in the tropics. The goal is to make the best possible use of TOPEX/POSEIDON altimetry data. This is being investigated by: (1) altimetric data processing and analysis (until TOPEX/POSEIDON data are available, Geosat altimeter data are used); (2) estimation of data errors due to orbit, tropospheric, and tidal error; (3) simulation of oceanic circulation using different numerical approaches (reduced-gravity model, Ocean General Circulation Model); (4) analysis of model sensitivity to wind error; (5) comparison of observed and simulated sea level variations; and (6) assimilation of altimetric data into numerical model of ocean circulation. Methods for fitting ocean models to altimeter data are investigated in three directions: (1) suboptimal estimation using updating (or nudging); (2) optimal estimation using Kalman filtering; and (3) optimal estimation using adjoint approach. The present RTOP is for the third year of the proposal. Objectives 1 and 2 are achieved with Geosat over the Indian Ocean, over the tropical Pacific, and for data error analysis. Objectives 3 and 4 are achieved with shallow-water model over the Indian Ocean (in collaboration with Dr. Delecluse), and Oceanic General Circulation Model (OGCM) (in collaboration with Dr. Chao) over the Pacific Ocean, models forced either with Florida State University (FSU) or European Center for Medium Weather Forecasts (ECMWF) winds. The next step is to run OGCM over the Indian Ocean (in collaboration with Dr. Delecluse). Objective 5 is well advanced: one publication, one submitted and two in preparation over the Indian Ocean, and two submitted over the Pacific. Objective 6-1 is being applied for El Nino predictions. Objective 6-2 was achieved for linear equatorial waves; it is being applied on other similar cases. Objective 6-2 was developed and is being applied to a shallow-water model.

W93-70431
578-22-24
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OCEAN CIRCULATION FROM SATELLITE ALTIMETRY
L.-L. Fu 818-354-8167

The long-term objectives of this study are: (1) to investigate the utility of satellite altimetry as a tool for studying the circulation of the global oceans; and (2) to explore ways to combine altimetry observations with ocean models to achieve an optimal description of ocean circulation and its variations. The data sets for the study include those from Geosat, ERS-1, and TOPEX/POSEIDON. We are in the process of establishing an end-to-end data processing
facility with the capability of data browsing, editing, gridding, orbit correction, tidal correction, mapping, and animation. Optimal estimation methods have been developed for correcting the orbit errors and the tidal errors, and also for space-time gridding and mapping. We have developed efficient schemes for applying Kalman filtering and smoothing techniques to assimilating altimetry data into ocean circulation models. Using these tools, we will conduct both descriptive and modeling studies. The following are the four near-term objectives. The first is basin-scale variability. We have generated a series of global sea level maps at a 5 x 5 degree grid and three-day interval using the Geosat Exact Repeat Mission (ERM) data. This work will be extended to the first 18 months of Geosat crossover data sets. The resulting four-year global data set will be used for studying the basin-scale variability and its relation to atmospheric forcings. The second is ERS-1 altimetry. Due to the non-repeating orbit of ERS-1, crossover analysis techniques will be applied to removing the orbit errors and constructing sea level time series for basin-scale variability studies. The third is modeling/data assimilation. Kalman filtering/smoothing techniques will be applied to assimilating the Geosat data into models of the Atlantic and the Pacific basins and eventually into a global coarse-resolution model (in collaboration with Dr. I. Fukumori). The fourth is TOPEX/POSEIDON data processing and evaluation. An operational procedure will be established to produce sea level maps from TOPEX/POSEIDON data. This activity will be funded largely by the TOPEX/POSEIDON Project. The sea-state bias will be evaluated using waveform analysis (in collaboration with E. Rodriguez).

W93-70432 578-22-25
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

STUDIES OF SEA SURFACE TEMPERATURE AND TOPOGRAPHY
V. Zlotnicki 818-354-5519
(578-22-27)
The goal of this work is to measure, understand, and help predict the circulation of the oceans at mesoscales and longer. Satellite altimetry, infrared, and microwave data combined with in-situ data, and data assimilation into a hierarchy of numerical models are the areas of emphasis. The current emphasis is on the three altimetric missions, Geosat, ERS-1, and TOPEX/POSEIDON. The main objectives for the coming year are: (1) to assess TOPEX/POSEIDON data, and tie it to the tide gauge network; (2) to assess and optimize orbit and environmental corrections to ERS-1 data by minimizing their discrepancy from tide gauge data; and (3) to combine TOPEX and ERS-1 altimeter crossover data with our existing Geosat Exact Repeat Mission (ERM) database, and ascertain whether interannual ocean changes can be distinguished from differences in the measuring systems. We will use: (1) a colinear difference adjustment, fitting a quadratically varying once/rev within an orbit arc, with tide constraint equations; (2) a similar approach to (1) for ERS-1 internal adjustment; and (3) a crossover adjustment between ERS and TOPEX data, fitting the time-averaged component of the altimeter’s observations. The principal investigator will devote 70 percent of the time to these tasks. An additional 10 percent of the time, funded under this RTOP, is used to manage all the activities of the Ocean Groups Computer System (RTOP 578-22-27). The remaining time will be devoted to the TOPEX project and Earth Observing System (EOS) interdisciplinary work. Funds are also requested for a half time programmer, to purchase meteorological data from the European Centre for Medium Range Weather Forecast, and to purchase selected in situ data from the National Ocean Data Center.

W93-70433 578-22-26
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LARGE SCALE AIR-SEA INTERACTIONS
D. Halpern 818-354-5327
(578-22-29)
Understanding the role of wind-driven ocean circulation in the dynamics of large-scale, seasonal-to-interannual variations of sea surface temperature (SST) and biogeochemical constituents, both in tropical and middle latitudes, is a basic tenet of the World Climate Research Program (WCRP) Climate Variability (CLIVAR) Program and of the Intergovernmental Panel on Climate Change (IPCC). Research on large-scale, long-period ocean-atmosphere interactions involves analyses of satellite observations and model simulations. Topics include the annual and interannual variations of the Pacific North Equatorial Countercurrent (NECC) and the space-time structure of the global surface wind field. During an El Nino, the geostrophic component of the NECC transport increases which suggests the NECC may be an important contributor toward the generation and maintenance of El Nino. In flowing eastward against the prevailing westward winds, the NECC represents an ocean circulation phenomenon whose dynamics have long interested oceanographers. The degree of Sverdrup balance throughout an annual cycle is not known because of the heretofore absence of suitable measurements. Geodetic Satellite (GEOSAT) estimates of the surface geostrophic current and simulations of the monthly transport of the Pacific NECC with an ocean general circulation model exhibited large variations in longitude. The surface geostrophic current was computed from GEOSAT data and will be continued with Earth Resource Satellite-1 (ERS-1) and Topographic Ocean Experiment (TOPEX)/POSEIDON altimeter data. The Remote Sensing Systems Special Sensor Microwave Imager (SSMI) surface wind speed field will be used to detect interannual variations and to evaluate improvements of the European Center for Medium Weather Forecasts (ECMWF) wind data product.

W93-70434 578-22-27
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

JPL OCEANOGRAPHY GROUP COMMON COMPUTER SYSTEM
V. Zlotnicki 818-354-5519
(578-22-25)
The goals of this task remain as in previous years: to provide a multi-user computer system serving the basic computing and data management needs of the Physical Oceanography and Biological-Polar Oceanography groups at JPL, both now and in their evolving roles in interdisciplinary studies. The computers funded under this RTOP are used to organize, process and analyze large volumes of satellite data and numerical model output. This RTOP assumes that a supercomputer, such as exists at Goddard, JPL, or Ames, are available to run numerical ocean models at no cost to either this RTOP or those of the investigators of the Oceanography groups, as has occurred for the past years. The computer system is based on a closely networked group of UNIX machines, mostly SUN’s, one Silicon Graphics, one Hewlett Packard, microVaxes and Macintoshes, and shared peripherals accessible to all members of the group. Some of the machines on the network are shared among all group members on an equal footing; other machines are task-specific, in that they were purchased outside this RTOP, but they are shared in a not-to-interfere basis with other group members. Upgrades to this Oceanography Computing Network (OCN) are dictated by the ever-increasing size of the data handled, and the increased sophistication of the analysis, modelling, and assimilation tasks performed. The open architecture, and standards such as UNIX and the SCSI interface, allows many economical upgrade paths. Between FY-88 and FY-90 this RTOP included all hardware and software requests for both groups. Starting in FY-92, our request includes only those needs common to many members, such as system managers, software maintenance, upgrades to large shared machines (the Silicon Graphics and Hewlett Packard), networking needs, etc. Hardware and software unique to a particular task are now requested and justified together with that task. The request for this FY includes system managers (1.5 wy), maintenance contracts for hardware and software, supplies (b/w and color ribbons and paper, magnetic tapes), increased disk space to provide convenient access to large on-line datasets, CD-ROM writer, an additional copy of IDL, and a second HP work station.
The unique perspective from space encourages observation of the global ocean, which is an essential component of the climatic system. Now, in the early stages of creating a long time series, it is appropriate to develop methods for presenting global multi-variable distributions. Halpern et al. (1992) published an atlas of monthly mean distributions of satellite measurements of surface wind speed, sea surface temperature, and sea surface height variation from Jan. to Dec. 1987. This was the second volume of the series. The first volume (Halpern et al., 1991) described 1988. The third volume, which covers 1989, will also be published in FY-92. The following monthly mean global distributions for 1987 and 1988 were presented with a common color scale and geographical map: sea surface height variation estimated from Geodetic Satellite (GEOSAT); surface wind speed estimated from the Special Sensor Microwave Imager (SSMI) on a Defense Meteorological Satellite Program (DMSP) spacecraft; sea surface temperature estimated from the Advanced Very High Resolution Radiometer (AVHRR/2) on National Oceanic and Atmospheric Administration (NOAA) spacecraft; and the Cartesian components of the 10-m height wind vector computed by European Center for Medium Weather Forecasts (ECMWF). Charts of monthly mean value, sampling distribution, and standard deviation value were displayed. The atlas also contained annual mean distributions. Near-surface current components computed from satellite-tracked drifting buoy motions will appear for the first time in the 1989 atlas, which will not contain GEOSAT sea surface height variations. An atlas of monthly mean distributions of oceanographic variables is a living document: no two months are identical. Additional atlases are required for interpretations of global climate variations and to provide internally consistent data sets for climate initialization and validation studies. This RTOP describes publication of annual atlases for 1990 and 1991, each of which will use data processing procedures similar to that employed in the previous atlases.

The goal of the proposed research is to characterize sea ice motion by combining observations from ERS-1 Synthetic Aperture Radar (SAR), Advanced Very High Resolution Radiometer (AVHRR), drifting buoys, ice station observations and meteorological fields (wind, pressure). Specifically, the proposed work will focus on the seasonal and regional behavior of ice motion in the Pacific Sector of the Arctic Basin covered by the Alaska SAR Facility (ASF) mask. This sector includes parts of the central Arctic, Beaufort, Chukchi and E. Siberian Seas. Sea ice motion will be partitioned into a large scale term and a small scale perturbation term based on the above observations. The large scale analysis provides a context in which to interpret the small scale behavior. In global system science, the large scale description is relevant to ice transport processes whereas the small scale description is important for characterization of local deformation and regional flux calculations. The spatial and temporal statistics of these motion terms will be analyzed. Interactions between the large scale and small scale motions will be quantified. Opening/closing calculations based entirely on kinematics will be compared with direct observations. Since E-ERS1 is one of the first missions to generate routine ice observations, it is also the intention of the studies to characterize the sensitivity of the geophysical measurements to errors in the observations from Synthetic Aperture Radar. The approach of the proposed work is to characterize sea ice motion using motion fields derived from ERS-1 Synthetic Aperture Radar (SAR) data, AVHRR data and drifting buoy data. We propose to combine these observations with ice station and meteorological observations to study the motion field in the Arctic at different length scales, from kilometers to thousands of kilometers. Specifically, we propose to study the regional and seasonal behavior of the ice motion in the Pacific Sector of the Arctic Basin. We will use the geophysical products as well as image products from the ASF. Although the operational limitations of ERS-1 will not provide the coverage for a synoptic view of the Arctic and peripheral seas, the SAR observations will nevertheless be able to answer some of the questions which have hitherto been unanswered due to lack of observational data.
major change. The data set of zonal boundaries will form a basis for monitoring their positions by subsequent mapping by the ERS-1 and other spaceborne SAR's. Finally, temporal monitoring on a monthly basis at four selected sites will be undertaken to investigate the nature and quantitative effect of seasonal changes on the backscatter signal. The approach is to develop techniques for mapping and change detection of SAR imagery. The primary tasks include (1) implementation of geocoding, terrain correction and mosaicking software to efficiently handle image data distributed by ESA; (2) compilation of the digital terrain data of the ice sheet; and (3) development of image analysis techniques for location of the zone boundaries in the SAR imagery.

W93-70440 578-35-04
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MONITORING THE SEASONAL CYCLE OF SEA ICE IN THE ARCTIC BASIN FOR CLIMATE CHANGE WITH ERS-1 SAR
B. M. Holt 818-354-5473

The principal task is to identify and monitor key seasonal transitions in the ice conditions in the Arctic Ocean that are discernible in ERS-1 C-band and JERS-1 L-band Synthetic Aperture Radar (SAR) imagery. The near-term objective is to determine the capability of these SAR's to monitor seasonal changes in sea ice and to assess the capability of the Alaska SAR Facility (ASF) ice classification algorithm for providing ice type and ice condition information by region and season. The approach will be to examine ERS-1 and JERS-1 SAR imagery of the Arctic Ocean acquired within the ASF station mask for seasonal variations as revealed in the backscatter signatures of the major ice types. The data will be analyzed by region and season. After calibration, the SAR signatures will be compared with scatterometer-derived signatures that are being utilized as look-up tables in the classification algorithm. The capability of the algorithm to assess these seasonal changes will be determined. The SAR data will be compared with other sensor data including Special Sensor Microwave Imager (SSM/I), Advanced Very High Resolution Radiometer (AVHRR) and LANDSAT imagery for clarification of features and ice type and environmental conditions. Any available measured ice parameters obtained coincident in time and location to ERS-1 and JERS-1 will be sought and used to verify ice type and condition. The signatures will also be compared to results of radar modeling efforts generated principally by co-investigator M. Drinkwater/JPL using ice and snow surface measurements. The thinner ice types have radar returns near the radiometric noise floor of the ERS-1 and JERS-1 SAR's and will be difficult to separate. The determination of thin ice will be examined by using zones of deformation derived from the ice motion analysis as indicators of areas of potential new ice growth. Later in the study a program will be designed and coordinated with other members of the science team who have utilized the ice classification algorithm to validate the functionality of the algorithm and to determine changes to the algorithm for improving accuracies, tracking of seasonal transitions, and replacing the scatterometer look-up tables with actual SAR-derived ice signatures.

W93-70441 578-60-00
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, MODELING
R. J. Koczo 205-544-3078

The objective of this RTOP is to conduct studies of atmospheric dynamics using numerical, experimental, and analytical models. Included are studies to examine baroclinic instability and its influence on the global circulation; diabatic processes affecting the thermodynamic energy budget; and the evolution of synoptic and planetary scale waves, including possible vacillation and/or scale interaction, with the objective of better defining the requirements for and applications of space-based sensor measurements. The approach will be to perform detailed analyses with theoretical models and ground-based data sets; to understand the role of latent heat release in the dynamics of cyclones; to examine global atmospheric processes to gain improved understanding of the scales of motion; to develop techniques for including satellite data in diagnostic procedures; and to develop strategies and mission concepts to measure global scale processes from space platforms.

W93-70442 578-41-01
Goddard Inst. for Space Studies, New York, NY.
GLOBAL CLIMATE MODELING
James E. Hansen 212-678-5619

The objectives of this RTOP are to develop and apply climate models to support NASA's Climate Program, particularly carrying out basic research which helps define observing systems requirements for monitoring, analysis and prediction of long-range climate change. 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, land hydrology, and the thermodynamic energy budget; and the evolution of synoptic and planetary scale waves, including possible vacillation and/or scale interaction, with the objective of better defining the requirements for and applications of space-based sensor measurements. The approach involves testing more realistic or accurate representations of these physical processes or numerical schemes, using the previously developed Model 2 as a control for these experiments. We plan to use the current Model 2 for climate studies aimed at obtaining a better understanding of global climate sensitivity and projections of transient climate change during the next 10 to 50 years. This includes experiments in which the global greenhouse forcing changes at a realistic rate on decadal time scales.

W93-70443 578-41-43
Goddard Inst. for Space Studies, New York, NY.
AN OCEAN GENERAL CIRCULATION MODEL FOR CLIMATE STUDIES
Inez Fung 212-678-5693

The objectives of this RTOP are (1) to investigate long time-scale natural variability in the climate system; (2) to investigate air-sea interaction in the North Atlantic; and (3) to reduce numerical diffusion in coarse-resolution ocean general circulation models. The major tool will be the global 3-D oceanic general circulation model (OGCM) developed by Bryan and streamlined at the Goddard Institute for Space Science (GISS). The model will be configured for sector geometry and run for greater than 1000 years with different off-line surface forcing to investigate internal modes of variation. The model will also be coupled to the GISS atmospheric general circulation model (GCM) to understand the ocean's role in natural climate variability. Surface exchanges of heat and fresh water will be re-examined using available conventional and satellite data and constrained by an inverse calculation and transports across 24 N. The surface fluxes will be compared with those derived from the atmospheric GCM to devise strategies for understanding and eliminating climate drifts in coupled models. Higher order finite-differencing schemes will be implemented in the OGCM to reduce numerical diffusion in the current model.

W93-70444 578-42-15
Goddard Space Flight Center, Greenbelt, MD.
SUBGRID VARIATION OF SURFACE PARAMETERS
David Toll 301-286-9256

The primary purpose of this research project is to examine subgrid-scale variations of the albedo, ground temperature, and surface heat fluxes using satellite data and available field observations. Case studies will use the resources from existing and future field programs (e.g., First ISLSCP (International Satellite Cloud Climatology Project) Field Experiment (FIFE), Hydrologic and Atmospheric Pilot Experiment (HAPEX), SPACE, BOREAS, etc.). The project will yield a number of scientific results that will lend insight into General Circulation Model (GCM) subgrid-scale problems and will provide work aiding in the application of existing parameterization schemes. The project results will quantify the measure of improvement that might be obtained when using selected procedures to estimate the subgrid effects. The results can also be used as guidelines for applying and developing parameterization procedures for planetary boundary layer parameters.
Biogeochemistry and Geophysics Modeling and Data Analysis

W93-70450 579-22-00
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL INVESTIGATION OF STRATOSPHERIC PARTICULATES
O. B. Toon 415-604-5971

The objective of the work is to contribute to NASA's Atmospheric Chemistry Modeling and Analysis Program in the area of quantifying the importance of heterogeneous chemistry. A sophisticated model of polar stratospheric clouds has been developed and used to study the properties of ice clouds and nitric acid clouds. The model has been used to investigate the mechanisms of stratospheric denitrification. Also included is a meteorological support task to manage and distribute data from aircraft field programs. Meteorological data including conventional global analyses and forecasts, and satellite cloud imagery is supplied to the field programs via NASA internet links into a field local area network (LAN) and direct satellite downlink. The field mission data is archived and published on compact disk read-only memory (CDROM) for distribution to the field participants and the community.

W93-70452 579-23-10
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

The goal of this task is to use a range of models, including 2-D and 3-D interactive radiative-dynamic-photochemical models, and complementary diagnostic studies to understand quantitatively the coupled chemistry and transport of photochemically important atmospheric trace species, as revealed by various satellite remote sensors: Limb Infrared Monitor of the Stratosphere (LIMS); Stratospheric and Mesospheric Sounder (SAMS); Atmospheric Trace Molecule Spectroscopy (ATMOS); Improved SAMS (ISAMS); Microwave Limb Sounder (MLS); Cryogenic Limb Array Etalon Spectrometer (CLAES), etc. We propose to look at the 3-D aspects of transport and photochemical modulation of ozone during spring in the Antarctic and during winter in the Arctic. While the area-mapping technique removes many of the transient effects due to advection within and evolution of the polar vortex, both Total Ozone Mapping Spectrometer (TOMS) and Upper Atmosphere Research Sounder (UARS) Microwave Limb Sounder (MLS) data suggest that the photochemical destruction of ozone is not uniform within the vortex. The distribution and duration of...
The objective of this program is to contribute to NASA's Atmospheric Chemistry Modeling and Data Analysis Program in the area of quantifying the effect of biomass burning and other emissions upon tropospheric radiatively active gases like ozone and methane, through computer simulation of these gases and associated gases that determine their levels. The approach is to construct, test, and apply one-, two-, and three-dimensional models of tropospheric trace species as they are photochemically transformed and transported away from their source regions. Emphasis is on large regional modeling and global-scale effects. The effort will be to construct the models, run the computer simulation models, and analyze the results for publication and comparison to remote-sensing and in-situ samples of tropospheric composition.

The objectives of this RTOP are as follows: (1) contributions will be made toward understanding the impact of potential climate perturbations on the stratosphere; (2) assessment will be made of the effect of any alterations in stratospheric dynamics on the impact of anthropogenic releases on stratospheric ozone; and (3) a better understanding of the expected changes to be observed in the next several decades will be attempted. The approach will be 3-D modeling of the troposphere/stratosphere/mesosphere system to delineate climate change influence on the stratosphere; results are saved for use with photochemical models.

The objective is to improve quantitative explication of global geomagnetic secular change in terms of its origin as an imbalance.
between motional induction and magnetic diffusion near the top of Earth's electrically conducting liquid outer core and the diffusion of this signal through the rigid, electrically resistive mantle. Technical objectives are to: (1) improve steady core surface flow estimates by allowing for mantle conductivity, core asphericity, and an uncertain initial magnetic field; (2) estimate deep mantle conductivity; and (3) study slowly varying core surface flow. The approach is to derive steady core surface flows from the Definitive Geomagnetic Reference Field (DGRF) models (IAGA, 1988b) and several mantle conductivity profiles using damped, weighted least squares. We seek the profile giving the best fit at a fixed, modest level of flow complexity. We plan derivation of both an initial core field model and a steady flow. Preliminary results should be ready by the start of FY-93. The initial field and flow are to be derived from the data, rather than DGRF models. Slowly varying core flow estimation is to be pursued after corrections for core asphericity.

W93-70459 579-32-06
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)
Carey E. Noll 301-286-9283
The Crustal Dynamics Data Information System (CDDIS) continues to fully support the data archiving and distribution requirements of the Crustal Dynamics Project (CDP) through December 1991. At that time, the CDP formally comes to an end and its successor, the Dynamics of the Solid Earth (DOSE) begins; the CDDIS continues to support DOSE in a similar fashion. The CDP was formed by NASA to apply space methods and technology to advance the scientific understanding of Earth dynamics, tectonics, and earthquake mechanisms. The Project uses three types of space-age techniques in this study: laser ranging to an artificial satellite or the moon, very long baseline interferometry (VLBI), and the global positioning system (GPS). As part of its data management, the Project has designed and implemented a centralized CDDIS. The CDDIS began operation in Sep. 1982. The main purpose of the CDDIS is to store all geodetic data products in a central data bank and maintain information about the archival of these data. The CDDIS is also tasked to disseminate these data products to Project investigators and cooperating institutions. The laser, VLBI, and GPS data sets accessible through the CDDIS fall into four major categories: preprocessed (Level 1), analyzed (Level 2 and 3), ancillary, and Project management data. The CDDIS is operational on a DEC Micro VAX II computer with nearly two Gbytes of on-line magnetic disk storage and 650 Mbytes of on-line optical disk storage (additional Gbytes are near-line; this system was upgraded to a VAX-4000 in fiscal year 1992 (FY-92). The CDDIS is accessible to Project investigators from remote, worldwide locations through the NASA Science Network (NSN-DECNet, NSN-Transmission Control Protocol/Internet Protocol (TCP/IP), and BITnet networks, through GTE SPРИНТnet, and through dial-in service.

W93-70460 579-36-03
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH ROTATION AND MANTLE STRUCTURE
C. F. Yoder 818-354-2444
This RTOP is intended to support general scientific research related to interpretation of Crustal Dynamics Project (CDP) earth orientation data (universal time, polar motion and nutation) and Lageos orbit perturbations, particularly the secular changes J2, J3, J4, etc. A layered earth model has already been developed to examine how viscosity structure and melting history affect present day changes in gravity field. A composite rheology model has been constructed which exhibits transient relaxation and which may be a reasonable model for the spherically symmetric component of mantle heterogeneity. A model describing the lateral dependence on viscosity structure shall be developed which uses the tomographic lateral velocity variations to infer temperature viscosity variations. The principal objective is to determine how well observables, such as the secular change in J2, and polar motion constrain viscosity structure. The second topic concerning earth rotation is the construction of a more complex semi-analytic nutation model which takes into account oceans, solid friction, and earth model uncertainties. In addition, the effect of the inner core, core-mantle boundary layer, 'figure-figure' core mantle coupling and the non-hydrostatic gravity field shall be examined. The principal objective for this task is to determine how well nutations constrain the core-mantle ellipticity, solid friction, J, and earth structural models. Finally, mechanisms which could account for non-tidal changes in universal time of order 200 sec on millennia time scales shall be examined.

W93-70461 579-36-09
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOPHYSICAL ANALYSIS AND MODELING OF LLR DATA
J. G. Williams 818-354-5466
The analysis of the lunar laser range data is intended to determine parameters of geophysical and geodetic interest as its final product. These parameters are station locations, their rates, earth rotation, gravitational coefficient (GM) of the earth, tidal acceleration of the moon, nutations, and the rate and pole of the precession of the earth in space. These determinations will contribute to precision geodesy and the understanding of plate motion, solid body rotation and ocean tides, the moments of inertia of the earth, and the earth's interior structure. The continued processing of lunar range data will improve upon the accuracies of these determinations as newer, more accurate ranges are received. The software needs improvements at the 1 to 2 cm level to fully use the 3 cm accuracy of the ranges being received from all three stations. Principal among these improvements are changes in the tidal displacements of the stations for variable Love numbers, solid body pole tide, and ocean loading. Also needed are rapid (diurnal and semidiurnal) ocean-tide driven earth rotation terms and the ability to solve for out-of-phase terms at one-half and one month. Also intended are upgrades to the software for operational efficiency. Published or submitted are results on precession, nutations, the earth's GM, and the tidally driven lunar secular acceleration. Other solutions have given a new value of the earth's GM. Earth rotation results have been submitted to the International Earth Rotation Service.

W93-70462 579-36-10
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RAPID EARTH ORIENTATION CHANGES
J. O. Dickey 818-354-3235
The rotation vector of the solid Earth exhibits complicated changes in both magnitude and direction over a broad spectrum of time scales, reflecting the influence of a wide variety of geophysical and astronomical phenomena. Our objective is to observe and define the interactions of the atmosphere and oceans with the rotational dynamics of the solid Earth (crust and mantle), in order to understand their contributions to the excitation of both length-of-day (LOD) and polar motion fluctuations. Our approach will involve detailed comparisons of space geodetic determinations with complementary geophysical data, including general circulation models (GCMs) of the atmosphere and oceans. We plan to utilize the existing Earth orientation data, especially those from the NASA Extended Research and Development Experiment held in 1989, the Global Positioning System (GPS) IERS Geodynamics (GIG) results from 1991, and those from the planned International Earth Rotation Service (IERS) campaign in 1992. In addition, we will analyze six hourly atmospheric angular momentum solutions from six hourly atmospheric angular momentum solutions from data collected during the First Global Atmospheric Research Project (FGGE) period, as well as results from the four operational centers (National Meterological Center, European Center, U.K. Meteorological Office, and Japanese Meteorological Agency).

W93-70463 579-36-11
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CORE-MANTLE EXCITATION
R. S. Gross 818-354-4010
The fundamental objective of this study is to gain greater understanding of the characteristics and origin of the observed decadal fluctuations in the Earth's rotation and polar motion. This
will be accomplished by deriving improved long term Earth rotation
sines, and then interpreting them in terms of possible geophysical
excitation mechanisms such as core-mantle coupling and the
cumulative effect of great earthquakes. The individual and
cumulative coseismic effects of earthquakes on other global
gеотrіс properties of the Earth will be studied as well. We will
study both the long term (century) and short term (decade) changes
that occur in these properties, as well as their interrelationships.
We will investigate core-mantle coupling and its excitation of Earth
rotation and polar motion using a multi-faceted approach. The
observed length-of-day and polar motion series and the inferred
three-vector torque will provide strong constraints on both
core-mantle coupling mechanisms currently being considered
(electromagnetic and topographic), thereby improving our
understanding of the core-mantle interaction and its excitation of
decadal changes in length-of-day and polar motion. For earthquake
excitation, 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
eigenfunctions of 1066B. For this calculation we will use
two different earthquake source mechanism data sets, namely:
(1) the centroid-moment tensor solutions being routinely determined
and published by the Harvard Group for all earthquakes having
seismic moment $M(\text{sub} 0)$ greater than $10^{24}$ dyne-cm; and
(2) the source properties for the greatest $M(\text{sub} 0)$ greater than
$10^{26}$ 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: (1) the secular drift of the Earth's rotation pole; (2)
polar motion; and (3) the Earth's shape as measured by changes
in baseline lengths and orientations.

**W93-70464**
Ames Research Center, Moffett Field, CA.

**IMAGE PROCESSING LABORATORY FOR TERRESTRIAL
ECOLOGY**
K. J. Weinstock 415-604-3327

The objective of this work is to provide general support to
NASA's science program in Terrestrial Remote Sensing. This RTOP
will insure that supplementary support is provided for the operation
of Ames Research Center's (ARC) Image Processing Laboratory
(IPL) and will contribute toward development of new capabilities
for the analysis of remote sensing and ecological data by incoming
senior scientists. The approach will be to provide support to the
IPL in the form of funding for ongoing computer equipment
replacement and upgrades and for one-time additions of specific
state-of-the-art equipment.

**W93-70465**
Goddard Space Flight Center, Greenbelt, MD.

**LTP COMPUTER SUPPORT**
Edward Masuoka 301-286-7508

The objective is to provide the best possible computing
environment for scientists in the Laboratory for Terrestrial Physics,
who are conducting research in Land Processes. The following
approaches will be used: (1) create a powerful computing
environment in the Laboratory computer facility by integrating UNIX
workstations into the VAXcluster as computer and file servers
and image analysis stations; (2) provide system administration and
networking support for scientists with UNIX workstations; (3)
provide support to assist scientists working with a common
suite of software for graphics and image processing; and (4) operate a VAX mn-computer to support scientists working on the First
ISLSCP Field Experiment (FiPE) and BOREAS project.

**W93-70466**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**ERS-1 STUDIES OF FOREST ECOSYSTEMS**
J. B. Way 818-354-8225

(462-41-51)

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 the ESA Remote
Sensing Satellite-1 (ERS-1) and Japanese Earth Resources
Satellite-1 (JERS-1) image data to be used in studying temporal
change (phenologic and environmental) in forest ecosystems. A
related RTOP (462-41-61) 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, JERS-1, and AIRSAR data sets of sites in the U.S.
including the Bonanza Creek Experimental Forest in Alaska, the Duke University Research Forest in North Carolina, and the Michigan Biological Station in Michigan. Ground truth measurements collected simultaneously with the aircraft and satellite data are being 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,
freeze-thaw, stress from frost, drought, and flooded conditions
were obtained in Alaska, summer drought stress and flooded
conditions were obtained over Duke, and winter snow and summer
rain/no-rain data sets were acquired over Michigan with AIRSAR.
Approximately 50 ERS-1 scenes were obtained over both Michigan
and Alaska between summer and winter of 1991. Additional data
sets will be acquired through 1994.

**W93-70467**
Goddard Space Flight Center, Greenbelt, MD.

**BIOGEOCHEMISTRY AND GEOPHYSICS MODELING AND DATA ANALYSIS**
William K.-M. Lau 301-286-7208

The objective of this RTOP is to analyze the variability and
response of the atmosphere to boundary forcings and examine
different aspects of land-atmosphere interactions. This approach
will conduct a ten year simulation with the new 17-layer model
under AMIP project and use the times series of this run to analyze
atmospheric response.

**W93-70468**
Goddard Space Flight Center, Greenbelt, MD.

**MODELING AND MULTISPECTRAL SATELLITE DATA
ANALYSIS FOR LAND SURFACE STUDY WITH SPECIAL
EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS**
Bhaskar J. Choudhury 301-286-5155

(461-13-01)

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
and semi-arid regions of Africa and Australia for the period
1979 to 1990 using the Scanning Multichannel Microwave
Radiometer (SMMR), the Advanced Very High Resolution
Radiometer (AVHRR), the Thematic Mapper (TM), and the Special
Sensor Microwave/Imager (SSM/I) data. Radiative transfer and
heat balance models will be developed to use daily or monthly
meteorologic data acquired from the National Climate Center to
simulate reflectances, vegetation indices, and surface temperature.
Methodology for correcting the satellite data for atmospheric
effects will be developed. SSMR and SSM/I 37 GHz data will be compared.
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.

W93-70469 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 as follows: to determine the accuracy, quality, and utility of topographic data derived from the Specialized Experimental Applications Satellite (SEASAT) and the Geodetic Satellite (GEOSAT) overland altimetry on a local, regional, and global basis; to develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and to demonstrate utility of satellite-derived topographic data for geological, geophysical, and hydrological problems, including monitoring seasonal changes in river levels. The approach will be as follows: to develop automated approaches to selection of GEOSAT repeat data over rivers for monitoring water level over time; to compare results with water gauge data in a blind test; to combine GEOSAT and SEASAT data in selective regions to produce a ten-year record of height changes; to evaluate the accuracy of these by detailed comparison of the profile data with existing high quality topographic contour maps produced locally for each continent; to produce contour maps for each continent along with maps showing the quality of the mean values derived for each grid point; and to assess the utility of the satellite-derived data for regional geophysical problems such as the mechanism of compensation of the Himalayas, and for geological problems such as the differences between ancient and modern stream gradients in the 'Trans-African Drainage System', water level change in ephemeral lakes, and uplift of shorelines due to post-glacial rebound.

W93-70470 579-42-11
Goddard Space Flight Center, Greenbelt, MD.

SATELLITE DATA SETS AND ALGORITHM TESTING
Donald W. Deering 301-286-9186

The objective is to develop and test techniques for extracting biophysical and other parameters related to land surface climatology on two continents. Ground and aircraft data are acquired as ground truth during intensive field campaigns coincident with satellite overpasses. The satellite data sets are acquired, processed, and analyzed to evaluate for the new study regions, as are algorithms that have been developed through research at other sites. Modifications are developed as required for the new areas.

W93-70471 579-42-13
Jet Propulsion Lab., California Inst. of Techn., Pasadena.

SOIL/CANOPY MOISTURE AND TEMPERATURE PROFILES USING REMOTE SENSING AND MODELING
E. G. Njoku 818-354-3693

The problem of retrieval of soil and canopy moisture and temperature profiles using passive microwave remote sensing is addressed by means of a unified remote sensing/modeling approach. Characterization of the seasonal moisture and temperature variations of the soil-canopy system is important for diagnostic analyses of regional climates and in the validation of general circulation models. Relations are developed for microwave radiative transfer through vegetation and soil. A state-space model is developed for heat and moisture flux in the soil-canopy system. These models are combined into a statistically optimal assimilation algorithm that uses remote sensing observations on portions of the system (namely the near-surface soil and vegetation) to update the state-space prediction of the soil-canopy profiles. The procedure is tested using simulated observational data and data from in situ, aircraft, and satellite instruments. The procedure initially emphasizes passive microwave observations but may be extended to include active microwave, visible, and infrared observations. The work in this RTOP is performed in collaboration with D. Entekhabi (Co-Principal Investigator) of the Massachusetts Institute of Technology.

W93-70472 579-43-00
Ames Research Center, Moffett Field, CA.

SPATIAL AND TEMPORAL DISTRIBUTION OF BIOMASS COMBUSTION AND PYROGENIC TRACE GAS EMISSIONS
J. A. Brass 415-604-3329
(463-67-08; 463-67-10)

The goal of this research is to develop and test methods of estimating fire extent and resultant seasonal and annual fluxes of trace gases at a regional scale, and to assess the relative impact on the atmosphere of biomass burning in several tropical eczones. Our approach includes the following components: geographic stratification to define eczones; analysis of comprehensive Advanced Very High Resolution Radiometer (AVHRR) and selected Thematic Mapper (TM) imagery of the Brazilian cerrado; and use of trace gas emissions data from other researchers. Fire activity products will be produced as a detailed intermediate product to be used for estimating gas emissions and as published information for other projects which investigate the impact of biomass burning at regional to global scales. Regional gas emissions over the annual fire season will make it possible to determine the role of tropical budgets of such gases as methane. Experimental products of weekly estimates at 1 degree will be produced as input for models of tropospheric chemistry currently under development.

W93-70473 579-82-00
Ames Research Center, Moffett Field, CA.

BIBLIOGRAPHY FOR LAND PROCESSES PUBLICATIONS
J. G. Lawless 415-604-5900

The objective of this work is to provide a bibliography to Headquarter's Earth Science and Applications Division that will document the peer-reviewed publications produced as a result of NASA's Land Processes Research Program (1984 to date). This bibliography will be used to determine the impact of the program and will be used by managers and scientists to identify articles of interest and trace the history and contributions of land processes research.

W93-70474 579-82-90
Goddard Space Flight Center, Greenbelt, MD.

COMPUTER AND INFORMATION SYSTEMS SUPPORT
Edward Masuoka 301-286-7608

The objective is to provide the best possible computing environment for scientists and staff who are managing research programs in land processes. The computing environment of the branch will be enhanced through the purchase of high performance Apple Macintosh computer systems for data analysis and image processing and networked peripherals for data storage and the production of high quality color output.

W93-70475 579-97-00
Ames Research Center, Moffett Field, CA.

GLOBAL CHANGE
J. G. Lawless 415-604-5900

The objective of this work is to provide general support for Ames Research Center (ARC) participation in NASA's Mission to Planet Earth Component of the Nation's Global Change Program. This RTOP will be used to provide support for planning a collaborative consortium of public and private institutions and agencies in California and the West. The approach will be to provide support for producing a final management plan and workshops as necessary to produce the science proposal for the consortium. In addition, the interface to efforts proposed by the Aspen Global Change Institute will be developed.

W93-70476 579-98-00
Ames Research Center, Moffett Field, CA.

LANDSAT LAND COVER PATHFINDER
E. J. Sheffner 415-604-6565

The Landsat Land Cover Pathfinder is one of five elements in the Pathfinder Program of the National Aeronautics and Space Administration (NASA). Pathfinder was developed as part of NASA's response to the U.S. Global Change Research Program. The objective of Pathfinder is to make archived data from satellite-borne
sensors applicable to global change research, and similar data currently being collected by operational satellite systems, accessible to the user community in formats and at costs that will stimulate global change research in the era prior to the launch of the first Earth Observing Satellite. The Multispectral Scanner System on the Landsat satellites has the longest continuous archive (twenty years) of global data of any satellite sensor. To make better use of this data, the Agency has formed the User Working Group. The function of the group is to provide guidance options to the Agency on how best to exploit the Landsat data base, especially what products to generate from the data base, how to disperse products to the science community and other users, and to define significant global change science issues that can be addressed by the data set. The Agency, and its cooperators, are also seeking support to perform research with the Landsat Pathfinder data.

The call for smaller, more cost effective missions places challenging requirements on mission data systems. They must be built quickly, inexpensively and for many, must interoperate with existing discipline systems. Reusable system building blocks are seen as a key element in data system interoperability. The key to fostering use/reuse of building blocks is to show the benefit of each in an environment which is operational, similar to the users' and demonstrates portability and maturity of the block. Understanding the driving requirements, emerging solutions and how they may be applied is the fourth objective of this task. OSSA disciplines have developed or are developing discipline specific archives, responding to the needs of discipline supported researchers. Developing multidisciplinary archives to support investigators asking questions requiring access to heterogeneous data archives is a new necessity for NASA.

W93-70475 656-61-03
Jet Propulsion Lab., California Inst. of Techn., Pasadena.
DATA INTERCHANGE STANDARDS
J. Grimes 818-354-3890
(155029049, 656-61-02)
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, and of providing a means to permanently describe data to avoid its loss. As part of this RTOP, a 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 when those organizations of persons generating the data are no longer available to consult. The work is based on the 'Standard Formatted Data Unit (SFDU) Concept', a technique under development by NASA in cooperation with 22 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 basic standards; the RTOP this year will refine these concepts and extend the standards in accordance with projects' needs. In addition, it focuses on (1) understanding the SFDU System environment and architecture at JPL, NASA, and internationally, and (2) the development of standard software tools to provide services for users working with SFDU's and other activities directly in support of projects at JPL. The effort is divided into the following major areas: (1) SFDU System Engineering: Participate, with CCSDS, in the definition of the SFDU system architecture and requirements, and in the establishment of standards based on that architecture, perform system engineering tasks including requirements and test definition for the phase 2 SFDU architecture and requirements; continue work on the SFDU toolset, and provide user support and feedback to SFDU developers (e.g., application engineering support for first-time implementors of the SFDU concept such as Mars Observer (MO), Magellan (MGN), Topographic Ocean Experiment (TOPEX), National Ancillary Information Facility (NAIF), Planetary Data System (PO, etc.)); (2) Continue the development of standard portable S/W tools for creating, manipulating, displaying, and managing SFDU products, and provide support to SFDU System Engineering by means of prototype information system development of advanced CCSDS Concepts; and (3) Develop and provide at JPL Control Authority services, including interfaces with data registrants and with other Control Authorities.

W93-70480 656-61-05
Jet Propulsion Lab., California Inst. of Techn., Pasadena.
NAVIGATION ANCILLARY INFORMATION FACILITY (NAIF)
C. H. Acton 818-354-3869
(15520-20, 656-61-03)
This RTOP develops and tests prototype software and data management technology, collectively called the Survey Probe Infrared Celestial Experiment (SPICE) system, that is used to facilitate the preparation, archiving, distribution, and user access to navigation and related ancillary geometry information required to obtain a full understanding of the science data returned from space-borne instruments. Accommodation is made for requirements that pertain to planning such observations, and for assisting with
O F F I C E O F A E R O N A U T I C S A N D S P A C E T E C H N O L O G Y

engineering aspects of mission operations. The work is conducted in direct response to recommendations of the National Academy of Science's Committee on Data Management and Computation. It is particularly relevant as instrument complexity, instrument data volume, and interest in correlative analyses grow. The work supports the objectives of improving the interpretation of science data while also reducing the OSSA-wide cost for production and use of necessary ancillary data through multimedia and multidisciplinary applicability. The National Ancillary Information Facility (NAIF) development approach follows recommendations to keep the space science community involved in all stages of SPICE development, including providing prototype component capabilities to scientists for evaluation in conjunction with ongoing research. With a major role in supporting flight project operations, NAIF must ensure that the SPICE standards and methodology are consistent with those of the relevant discipline data systems.

W93-70481 656-61-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PDS: DATA DISTRIBUTION AND ARCHIVE TECHNOLOGY
S. K. McMahon 818-354-6040 (155-20-40)
The overall objective of this RTOP is to improve data distribution plus archive technology and methods for science data systems. It uses the Planetary Data System (PDS) as the initial testbed, but the technology and methods developed are applicable to data systems of all disciplines. There are two parts to this RTOP, labeled as A and B below. The objectives of Part A are to continue the Data Distribution and Archive Lab at JPL. This facility will do the following: (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 System Concept, where CD-ROM's contain full sets of documentation, catalog, geometry, software, and data; and (4) evaluate optical and magnetic data storage media for both data distribution and data systems. As a complement to the technology enhancement objectives, an equally important objective, Part B, 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: (1) very large data volumes; and (2) transfers from the flight projects with distributed data systems. The approach used for Part A will be to support PDS data preservation work. It will also coordinate with and support archiving efforts of other data systems (National Space Science Data Center (NSSDC), NASA Ocean Data System (NODS), Multimission Image Processing Laboratory (MPL), 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. The approach for Part B will be 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. Lessons learned from the prototyping on risk avoidance and cost reduction will be passed on to other discipline archive systems.

W93-70482 656-61-07
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE DIGITAL DATA PRESERVATION
S. LeVoie 818-354-5677 (186-00-00)
The objectives of the RTOP are as follows: inventory and evaluate all tapes (135,000); preserve valuable data currently residing on 50,000 tapes and make the data more accessible to the user; further reduce the volume of tapes by converting to a higher density media and disposing of duplicate data; and transfer converted tapes and archive responsibility to the appropriate archive facilities. The approaches are as follows: (1) Phase 1 - Inventory and Evaluation (begun in FY-90; will be completed end of FY-92) - recall all tapes; organize, inventory, and catalog tapes; evaluate tape value under guidance of Science Data Evaluation Board (representatives from science and technical community knowledgeable about the data). Planetary Data System, and Planetary Science Data Steering Group (PSDSG); prepare valuable data for conversion; distribute or dispose of duplicate data; publish Phase 1 report; evaluate conversion alternatives for both archive media and hardware/software approach (in preparation for Phase 2); and publish Draft Conversion Plan and Schedule; and (2) Phase 2 - Conversion (begin FY-93) - establish data set conversion priorities relevant to existing inventories of Solar System Exploration data sets; convert all valuable data to higher density media; generate catalog of tape contents; transfer tapes and archive responsibility to Planetary Data System or appropriate JPL or NASA facility, National Space Science Data Center (NSSDC) and JPL Archives; and publish task final report.

W93-70483 656-61-13
Goddard Space Flight Center, Greenbelt, MD.
SS FREEDOM ARCHIVE PLANNING STUDY
Joseph H. King 301-286-7355
This RTOP started as an assessment of the optimal roles for National Space Science Data Center (NSSDC) in the management and archiving of data from life science and microgravity missions. Workshops held, with co-sponsorship by the Life Science and Microgravity Divisions at Headquarters/Office of Space Science and Applications (OSSA), and workshop reports, including recommendations, were issued. For both disciplines, Discipline Data Systems role is being developed outside NSSDC, with some NSSDC consulting. In addition, a Discipline Data Systems Lessons Learned Document was created, capturing the experience of extant OSSA Discipline Data Systems.

W93-70484 656-61-17
Goddard Space Flight Center, Greenbelt, MD.
NSSDC ASTROPHYSICS DATA SYSTEMS SUPPORT
Michael E. VanSteenberg 301-286-7876 (399-30-00)
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: (1) Generic On-Line Data Access/Distribution Tools; (2) Generic On-Line Documentation/Literature Tools; and (3) Application of Generic Tools as ADS Services. In the first facet we plan to provide additional generic software tools, either through complete development or re-use of existing tools from outside sources (i.e., Code FY 91) are being developed in general science community produced code), that will enable the general scientist to stage or promote data from near- and/or off-line status to on-line status; examine or browse data that has been staged; and extract or subset data for distribution. In the second facet we plan to develop generic software and hardware tools that will support digitization of textual data (dataset documentation/literature); maintenance and storage of digitized textual data using existing facilities; searching, examination, and browsing of the textual data (image and text); integration of distribution by request through existing facilities; and on- and near-line access to pertinent textual data. In the third facet we will install the tools developed in the above. In particular, we will establish services at the NSSDC ADS node which include data selection, staging, browsing, and extraction for the Astronomical Data Center (ADC) on-line catalogs; the National Space Science Data Center (NSSDC) held archival data; and access to electronic on- and near-line documentation and literature.

W93-70485 656-61-18
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS DATA SYSTEM
R. E. McGuire 301-286-7794
A primary goal of NASA space science missions is the collection and analysis of scientific data. Often, however, the handling of flight project data has been an 'afterthought' lost in the press to successfully build and fly new instruments and to make the first and most exciting of the new discoveries always
An increasingly urgent issue in the management of the scientific data collected from past NASA missions is the need to migrate critical data to new media and take other actions in documenting or forming data to assure its preservation and optimal future usability. This multi-year RTOP will enhance the efforts already underway at the National Space Science Data Center (NSSDC) to identify, prioritize, migrate to new media, document and otherwise more effectively manage and make accessible the most important data in the current NSSDC archive. Elements of planned work include (1) interactions with Office of Space Science and Applications (OSSA) discipline offices and the designated representatives of their science communities to determine the importance of various NSSDC data holdings for archival retention and restoration targets; (2) direct migration of important data from older media to new media, with backups and appropriate plans and procedures defined to assure the subsequent retention of such data; (3) improvements in documentation, validation, formats, near-line/on-line access, and data publication (e.g., via CD-ROM) and/or more specialized recovery efforts to improve usability of critical data; and (4) safe archival storage data in fully National Archives and Records Administration/National Institute of Standards and Technology (NARA NIST) and industry standards compliant facilities.

W93-70486 656-61-20
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY HARDCOPY PRESERVATION TASK
L. J. Pied 818-354-8320
(656-61-57)
Much planetary flight project data exists in a variety of hardcopy media (film, printer paper, computer listings, drawings, photographic paper, plots, etc.). These data are produced during the active mission phases, but are valuable in a post-mission analysis phase. It is important to ensure the preservation of these products for long-term science community access. The objectives of this RTOP are (1) the proper identification, evaluation, disposition recommendations, handling and storage techniques, reproduction and/or appropriate media conversion for these hardcopy products; and (2) preservation of valuable hardcopy planetary data for use by the planetary science community. This effort will examine and assess planetary data products from the Voyager Imaging Library and other JPL post-mission collections housed in the JPL Regional Planetary Image Facility; coordinate with the PDS and the SDDRT activity to establish general priorities, products which should be disposed of, adequately stored in the current media for long term preservation, or converted to a different media or reproduced/restored; recommend, based on research and coordination with other institutions concerned with the preservation of hardcopy products, application of adequate storage techniques or conversion techniques, and ultimately ensure product life through media conversion, adequate storage methods or reproduction. FY-92 deliverables focused on contacting members of the planetary community and familiarizing them with the task and obtaining the Science Data Evaluation Board (SDEB) approval to act as the reviewing board for this task; and developing policies and procedures for disposition, performing initial data set identification and storage assessment, and producing a high-level identification/assessment database. FY-93 activities will include: interacting with the SDEB, PDS Council Members and PSDSG on data set preservation priorities; continuing discussions with the National Space Science Data Center (NSSDC), SDDRT, PDS, and NASA personnel in identifying dataset redundancy and uniqueness; obtaining SDEB/PDS review/approval on final data disposition policies and procedures; performing detailed evaluation of datasets by contacting knowledgeable personnel about dataset details; sizing the handling and conversion requirements for those products deemed valuable for long-term retention; and reporting on task status monthly. Future activities include implementing adequate handling and storage techniques; investigating data conversion options for those products deemed by PDS Council/SDEB to be valuable for long-term preservation; and establishing conversion schedules in conjunction with PDS/PSDSG.

W93-70488 656-65-04
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGE ANIMATION LABORATORY FOR SCIENCE VISUALIZATION
D. F. Stantiff 818-354-3742
(656-65-06; 186-00-00; 656-74-03)
This task will develop 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. This development will assist scientists in their research: Earth Scientists, Planetologists, and Astrophysicists use several dimensions to address many of their problems, yet most data are represented and analyzed in 2 dimensions. Interactive tools will be developed in a workstation environment to properly combine and then visualize multidisciplinary data in several dimensions. These tools include visualization and analysis of very high resolution terrain data (elevation and/or imagery) mapped onto planar or quadric surfaces, volumetric data, and other multidimensional data. In addition, the tools include two and three dimensional animation, 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. The approach of this RTOP is to use a task team - consisting of the scientists whose data is to be visualized and programmers - to further visualization capabilities in a manner consistent with achievable technology and scientific utility; and design and implement the software for portability and extensibility (i.e., generic X-windows implementations) using commercially available general purpose computing platforms (Sun SPARC, Silicon Graphics IRIS). This includes a 'scientist friendly' user interface. Additional data types will be incorporated by extending existing techniques and developing new techniques. The methods, techniques, and tools developed in previous FY's will be generalized to handle a broader range of scientific data and will be delivered to scientists for feedback.

W93-70489 656-65-05
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAPHICAL METHODS FOR SCIENCE VISUALIZATION AND DATA ANALYSIS
A. S. Jacobson 818-354-0693
The long-term objective is to apply computer graphics methods and technologies to the interactive display, manipulation and analysis of large data sets. The specific objectives of the program are (1) to develop a software environment which will support the rapid prototyping of visual data analysis applications, while at the same time maintaining the high level of performance necessary
for interactively manipulating graphical displays; (2) to develop a user interface that is truly intuitive and easy to learn and allows quick access to the software for the novice as well as the advanced user; (3) to provide a suite of sample applications which are useful across a variety of scientific disciplines; and (4) to provide tools to support user development of applications for this environment.

This is accomplished by a process of prototyping and using applications in close collaboration with scientific teams, engaged in research and data analysis in a variety of disciplines. The Linked Windows Interactive Data System, or LinkWinds, is the current prototype product of this research. It is a visual data analysis/exploration system designed to rapidly and interactively investigate large multivariate and/or multidisciplinary data sets to detect trends, correlations and anomalies. It is currently being used at several sites both within JPL and at outside institutions.

W93-70490 656-65-06
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SOLAR SYSTEM VISUALIZATION (SSV): SCIENTIFIC TOOLS FOR NASA/JPL IMAGE ARCHIVES
F. M. DeJong 818-354-0302
(656-65-04; 656-61-07; 656-74-03; 196-41-71)

The first objective is to create a realtime, interactive, scientific visualization environment which allows scientists to personally control all aspects of visualization, analysis, and data assimilation processes. The goal is realtime interactive visual comparison of data with scientific models. The second is to develop a prototype high performance science analysis workstation and an inexpensive previewing image animation workstation, and to adapt existing tools and develop new scientific tools for use with the NASA/JPL solar system exploration archive. The workstations will be testbeds for evaluating and comparing new computer algorithms and architectures. The third is to create planetary science Image Data Sets (IDS), and scientific visualization and analysis problems. The image data sets and problems would serve as benchmarks. They would be used to compare and evaluate new visualization and analysis algorithms/systems, and as educational material. They will be stored on CD-ROM for inexpensive distribution. The fourth is to integrate and test these tools and to provide a quantitative assessment of the achievement of the first three objectives. Scientific tools, image data sets and benchmark programs will be developed to meet the needs of the planetary science community, as reflected by current flight projects. The Earth, from a global/planetary perspective, will also be included. The SSV science team will test the effectiveness of the visualization, scientific analysis, and data assimilation tools. Collaborations will be developed with flight projects, including: Mars Observer, Mars Environmental Survey, Magellan, Galileo, and Ulysses.

W93-70491 656-65-07
Goddard Space Flight Center, Greenbelt, MD.

CENTER OF EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)
J. M. Hollis 301-286-7591

The objective is to operate a center at GSFC a Center of Excellence for Space Data and Information Sciences (CESDIS) which will consist of a consortium of university, industry, and government scientists engaged in computer science research addressing NASA's long-term space and Earth sciences data and computational problems. This RTOP will support a contract with the Universities Space Research Association (USRA) to administer, coordinate, and manage the award of grants to participating universities; to negotiate appointments of industrial and government associates to CESDIS; to conduct periodic peer reviews of CESDIS by the USRA Council; and to act as the interface between NASA and CESDIS.

W93-70492 656-65-21
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DATAHUB - KNOWLEDGE-BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES
T. Handley 818-354-7009
(656-65-05)

This RTOP addresses four areas of significant need: scientific visualization and analysis; science data management; interactions in a distributed, heterogeneous environment; and knowledge-based assistance for these functions. The fundamental innovation embedded within this RTOP is the integration of three automation technologies, via knowledge-based expert systems, science visualization, and science data management. This integration is based on a concept called the DataHub. With the DataHub, NASA will be able to apply a more complete solution to all nodes of a distributed system. Both computational nodes and interactive nodes will be able to effectively and efficiently use the data services (access, retrieval, update, etc.) in a distributed, interdisciplinary information system in a uniform and standard way. This will allow the science investigators to concentrate on their scientific endeavors, rather than to involve themselves in the intricate technical details of the systems and tools required to accomplish their work. Thus, science investigators need not be programmers. The emphasis will be on the definition and prototyping of system elements with sufficient detail to enable data analysis and interaction leading to publishable scientific results. In addition, the proposed work includes all the required end-to-end components and interfaces to demonstrate the complete concept. The DataHub will also be coupled as a data provider with the science data analysis tools/environments LinkWinds.

W93-70493 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 seek to combine high-resolution remote sensing data with ground truth measurements and radar image models in the context of a Geographical Information System (GIS). The GIS database 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 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 will also be used to validate the radar models, which are based on ground data measurements. We will make use of a unique set of calibrated synthetic aperture radar (SAR) data at two forest sites, together with ground data maps and data from optical/infrared (IR) sensors. This data will be incorporated into a JPL-developed GIS database, termed Video Image Communication and Retrieval (VICAR)/Image Based Information System (IBIS). We will use the software at our disposal to geocode the radar data, classify, analyze and visualize it, correlate it with data from other sources, and model the radar backscatter response to changes in key biogeoophysical parameters. Existing image processing software will be integrated into the GIS in a ‘toolkit’ format, which can be easily extended for additional applications.

W93-70494 656-65-24
Ames Research Center, Moffett Field, CA.

CONSTRUCTION OF AN ADVANCED SOFTWARE TOOL FOR PLANETARY ATMOSPHERIC MODELING
H. Lum 415-604-6544
(595-12-22)

The construction of scientific software models is an integral part of doing science, both within NASA and within the scientific community at large. Typically, model-building is a time-intensive and painstaking process involving the development of very large, complex computer programs. Despite the considerable expenditure
of resources involved, completed scientific models cannot easily be distributed and shared with the larger scientific community due to the complex, idiosyncratic nature of the implemented code. To address this problem, this research proposes constructing a software tool called the 'Scientific Modeling Assistant' that serves as an aid to the scientist in developing, using, and sharing models.

To facilitate model-building, we propose building a software system that incorporates an interactive intelligent graphical interface, a high-level domain-specific modeling language, a library of physics equations and experimental datasets, and a suite of data display facilities. Rather than construct models using a conventional programming language, scientists will use our graphical interface to 'program' visually using a more natural high-level data flow modeling language. In constructing this tool, we will use a variety of advanced software techniques, including artificial intelligence techniques, as well as techniques from object-oriented programming, graphical interfaces, and visualization. To test this approach, we will build a software prototype in the domain of planetary atmospheric modeling.

W93-70495 656-65-25
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MULTI-CHANNEL HOLOGRAPHIC BIFURCATING NEURAL NETWORK SYSTEM FOR REAL-TIME ADAPTIVE EOS DATA ANALYSIS
A. Walton 818-354-3469

The overall objective of this RTOP is to produce an optical adaptive resonant system (OARS). To achieve the objective, the work is divided into three phases. During the first phase, the underlying behavior of the OARS including the data throughput capacity, cross-correlation interference, fault tolerance, and signal-to-noise ratio properties are studied via theoretical analysis and experimental test. The objective of the Phase 2 work is to investigate hardware implementation for breadboard demonstration. The third phase objective is to see how the system can be used for Earth Observing System (EOS) data analysis and other applications. The approach to achieve the RTOP objective includes the state-of-the-art techniques of free-space holographic interconnection and optical parallel processing capabilities with multi-channel input capacity. The multi-channel input is realizable by holographic optical elements (HOEs) and high speed updatable Spatial Light Modulators (SLM's). Photorefractive crystals will be used for the formation of the bifurcating decision-making process. The OARS has a 'brain-like' nature. In the implementation of an OARS, we store the a priori known objects in photorefractive crystals in holographic grating form with the unique features of artificial plasticity for self-programming capability. Then any new input can be compared at high speed with the stored images for recognition and classification.

W93-70496 656-65-26
Goddard Space Flight Center, Greenbelt, MD.

A SPATIAL ANALYSIS AND MODELING SYSTEM FOR ENVIRONMENTAL MANAGEMENT
F. L. Stetina 301-286-5717

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. The Spatial Analysis and Modeling System (SAMS) is based on an enhanced version of the Federal Emergency Management Administration's (FEMA's) Integrated Emergency Management Information System and the Department of Defense's (DoD's) Air Land Battlefield Environmental Software Systems. The approaches are as follows: (1) to complete the system integration and software development plan; (2) to work with the U.S. Corp of Engineers and FEMA to select the test site for flood plan forecast and hydrological applications model selection; (3) to complete evaluation of image processing software, Geographical Information System (GIS) software, and system integration software; and (4) to complete development of satellite precipitation maps over the test site area.

W93-70497 656-65-27
Goddard Space Flight Center, Greenbelt, MD.

A DISTRIBUTED ANALYSIS AND VISUALIZATION SYSTEM FOR MODEL AND OBSERVATIONAL DATA
S. E. Koch 301-286-7188

The objective of this RTOP is to develop an integrated and distributed analysis and display software system for visualizing the massive amounts of data generated from satellites, observational field programs, and from model simulations during or after their execution. Components of the system will include General Meteorological Package (GEMPAK) analysis, data handling, and graphics capabilities (developed by NASA) and prototype software for three-dimensional interactive display and animation built at National Center for Supercomputing Applications (NCSA). Overall process control will be handled through evolving scientific application and visualization builder tools on UNIX-based supercomputers and workstations.

W93-70498 656-74-03
Jet Propulsion Lab., Califorina Inst. of Tech., Pasadena.

CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS
M. Lee 818-354-2228 (656-65-04; 656-65-05; 656-65-06; 656-61-05; 186-00-00)

The major objective of this task is the extension of concurrent processing of testbed technology to an integrated science analysis environment. In the context of the National High Performance Computing and Communications (HPCC) Program, this includes providing a 'transitional environment' between modest performance (100 MFLOP's), concurrent systems, and systems capable of gigaflop to teraflop performance. The four major elements of this objective are the following: (1) development and demonstration of integrated science analysis and visualization tools; (2) development and demonstration of a data/information management system for a distributed/concurrent computing environment; (3) development of techniques and utilities for heterogeneous distributed computing resources to support computationally intensive science analysis activities; and (4) development and demonstration of portability concepts in high performance computing architectures, wide area networks, and large data storage facilities. The approach to meeting these RTOP objectives draws heavily on the experience gained over the past few years in development and implementation of the concurrent processing testbed, the Concurrent Image Processing Environment (CIPE), and the Planetary Analysis Tool (PLATO) set. In addition, the experience gained in applying this technology to real-time science information extraction during the Voyager Neptune Encounter, Hubble Saturn Storm Study, and Magellan Mission will continue to be applied to the development of analysis tools and algorithms which are capable of handling the volume and complexity of data represented by the Earth Observing System (EOS), Galileo and future planetary exploration missions. Focus for development and demonstration of science analysis capabilities will be provided by specific problems in current missions such as Planetary Atmospheric and Surface Topology Studies in support of Galileo Earth 2 Encounter and Magellan Data Analysis tools. The research team will work closely with a selected set of NASA scientists in the articulation of needs, the evaluation of potential solutions, and the development and testing of specific products. The products will be distributed to the science investigator community as part of the evolution of the PLATO set.

Mission Operations and Data Analysis

W93-70499 665-35-00
Ames Research Center, Moffett Field, CA.

ERS-1 SAR INVESTIGATIONS OF METHANE EMISSIONS FROM HIGH LATITUDE ECOSYSTEMS
L. A. Morrissey 415-604-3617
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

The objective of this research is to assess the role of northern wetlands in the global methane budget. The approach utilizes aircraft (AIRSAR) and ERS-1 satellite radar data to seasonally monitor environmental parameters as they relate to methane emissions: wetland inundation levels (providing an anaerobic substrate for methanogenesis), vegetative leaf area (plant-mediated transport pathway for methane), and phenology (period of biological activity for methane bacteria). Physically-based radar modeling of multifrequency, multipolarized AIRSAR will be conducted to understand the physics of radar interaction with wetland vegetative and hydrologic parameters. These radar-derived data layers will be integrated into a geographic information system to improve current seasonal and regional estimates of methane emissions.

W93-70500 665-35-01
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AFS SAR INTERFEROMETRY
H. A. Zebker 818-354-8780

We propose to apply interferometric radar topographic techniques to the study of active Alaskan volcanoes, motion and stress of glaciers, and permafrost cycle heating of the surface. Since radar interferometry permits mapping of surface heights, changes in surface heights, and surface lateral displacements, it is an appropriate tool for the study of these phenomena. The ERS-1 radar and Alaska Synthetic Aperture Radar Facility (ASF) will provide data from which we may derive topographic maps of 10 m height accuracy over images tens of kilometers in extent at a spatial resolution of 20 to 30 m. It may also be possible to generate topographic change maps, on a relative rather than absolute scale, sensitive to cm scale changes in height that may serve as precursors to eruptive events. These changes in height may also be used to monitor the ground heaving associated with the thawing of soil layers in the Arctic regions. We plan to monitor the thickness above the permafrost layer as the ice melts, thereby, causing the absolute height of the ground to drop as the water drains from the layer. Finally, displacements of the surface as small as a fraction of a 6 cm wavelength are observable in the interferometer images. This property allows us to track glaciers even as they move at very slow rates. Since we measure many 20 m resolution elements on a typical glacier, any differential motion which can lead to stresses in the ice may be monitored. Our approach is to utilize ERS-1 data acquired during the commissioning phase and during the ice three day repeat orbit in order to achieve maximum correlation between the radar signals. These data will be processed to complex images, and interferograms between pairs of data sets will be derived. These interferograms are then reduced to topographic maps if altitudes at a few tie points are known; also any shifts in position (motion) may be ascertained. The interferogram pairs may then be combined to measure the topographic change in an area, which is needed for the permafrost investigation. Any systematic errors in height estimation are removed in this process, so that the resulting sensitivity to change is on the scale of cm.

W93-70501 665-35-09
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ESTIMATION OF GREENLAND SEA BRINE AND FRESHWATER FLUXES FROM ERS-1 AND SSM/I DATA
F. D. Syes 818-354-8163

The principal objective is the estimation of fluxes of brine and freshwater from sea ice formation and melt in the Greenland Sea with emphasis on brine production in the winters of 1989 and 1992. This flux densifies the mixed layer of the Greenland Sea and drives the deep convection that is the primary source of Atlantic Intermediate Water: This process is known to be active, in some but not all winters, in the region of the Greenland Gyre centered near 0 degrees E, 74 degrees N. Fresh water fluxes through Fram Strait are a significant aspect to air-sea interaction in the Greenland Sea. The estimates will be drawn from a combination of ERS-1 Synthetic Aperture Radar (SAR) data available at European stations, Special Sensor Microwave/Imager (SSM/I) microwave brightnesses, and environmental analyses. The approach will be to use: (1) SAR analysis to track the ice and to provide open-water production; and (2) SSM/I data, using algorithms which we are developing to monitor the development of the ice cover in time. The brightnesses in the SSM/I wavelengths have previously been shown to be sensitive to the growth of the ice from open water to about 30 cm thickness where the ice attains the radiance of thick first-year ice. Key issues to be addressed are the sensitivity and noise levels in the SSM/I brightnesses and the accuracy with which the ice motion data can generate estimates of opening and closing of the ice. This project is conducted in collaboration with U.S. and European investigators in the Greenland Sea Project; the in-situ oceanographic data collected by that project will serve as auxiliary data and validation data. In sum, three methods will be used to estimate the brine flux: (1) SAR analysis, the SAR+SSM/I analysis, and a bulk flux formulation; an error-minimizing procedure, such as Kalman filtering, is ultimately envisioned to select the most likely flux quantity. Fresh water fluxes will be addressed through the estimation of ice areal flux through Fram Strait multiplied by the ice thickness data to be acquired by upward-looking sonar on a mooring.

W93-70502 665-35-10
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ERS-1 SAR INVESTIGATION OF ICE KINEMATICS AND SURFACE WIND FIELDS IN THE WEDDELL SEA
M. R. Drinkwater 818-354-8189

The investigation will be continued into coupling between surface winds and sea ice in the Weddell Sea, Antarctica on scales of 100 sq km. The objective is to order ERS-1 Synthetic Aperture Radar (SAR) image data, downlinked to the German Antarctic Receiving Station (GARS) on the Antarctic peninsula, through a period of ongoing intensive surface experiments during February to August 1992. Surface experiments will be conduced aboard the research vessel Polarstern between May and August to monitor wind stress and ice divergence in conjunction with Argo buoy deployments. Ice kinematics data, extracted automatically from SAR image pairs using the Geophysical Processing System (GPS) at the Alaska SAR Facility, will be combined with ice divergence data supplied from the Argo drifter arrays and then compared with the wind stress data. An investigation of the momentum balance and derived empirical relationships between wind stress and sea ice divergence will be used to simulate and hindcast the wind speed and direction from gridded ice motion fields. The objectives of this RTOP are: (1) to acquire and process ERS-1 SAR data already collected in the Western Weddell Sea, from the German processing and archiving facility. Further data requests will be placed for simultaneous coverage in the Eastern Weddell Sea during the Winter Weddell Sea Polarstern experiment in the time window from 27 June to 30 July; (2) to generate ice motion and other GPS products from the Western Weddell Sea SAR data collected in the three-day PIPOR orbit phase and combine these with Argo drifter deformation at approximately 50 km spacing around Ice Station Weddell, to establish the relative ice motion field around the ice camp; (3) to participate in the Winter Weddell Sea Gyre Study aboard RV Polarstern on experiment Ant X/4 between May 21 and August 5, 1992; and (4) to analyze buoy motions and satellite-tracked corner reflectors to validate three-day SAR motion products and to investigate the integrity of short-term ice motion field. The approach is (1) to generate images and geophysical products from Weddell Sea ERS-1 images using the Alaska SAR Facility (ASF) Geophysical Processing System; (2) to display and create gridded ice motion fields using available three-day repeat image pairs from the ice orbit and from the 35-day repeat orbit, multi-disciplinary phase of the ERS-1 mission; (3) to conduct buoy and corner-reflector array deployments and participate in acquisition of supporting meteorological, microwave, and surface characterization measurements from the Polarstern vessel during the AnZone experiment; and (4) to evaluate ice motion fields in the Weddell and Eastern Weddell Sea and to test existing empirical relationships derived from the ice momentum balance which relate air-ice stresses with ice divergence, drift speed, and turning angle.
The primary objective of this project is to address the question of how NASA Earth science data relating to Global Change will be made useful to middle school students for educational purposes. Students must learn: (1) the elements of the scientific method, as applied to working with real data; (2) the operation of software such as spreadsheets, image processing, and word processing tools; and (3) some facts and approaches to the study of global change issues, such as multispectral classification of images, picture differencing, calculation of regional and zonal mean quantities, using time-series (stratigraphic) information, comparative planetology, and budget calculations. Our approach is to produce a workstation environment that includes as utilities the necessary tools, together with databases of relevant digital image, video, and tabular material, and a structured set of interactive explanations and examples we refer to as the 'tell' and 'ask' modes of operation. Project development is organized around a science team, which is responsible for content and validity of the material, an education team, which leads the classroom model development and field testing activities, and works with the science team to set the level of explanation, and a technical design team. This RTOP supports the project scientist, who has also had primary responsibility for developing the workstation concept described here, and is science team leader. The content of the tell and ask modes is divided into a 'Pilot' Project and the Full Project. The Pilot Project is intended to test innovations in content, educational style, and technical design. It focuses on basic classification and tabular material, and a structured set of interactive explanations. The Full Project will include more advanced topics, such as greenhouse warming, simple photochemistry and the ozone hole, and examples we refer to as the 'tell' and 'ask' modes of operation. Project development is organized around a science team, which is responsible for content and validity of the material, an education team, which leads the classroom model development and field testing activities, and works with the science team to set the level of explanation, and a technical design team. This RTOP supports the project scientist, who has also had primary responsibility for developing the workstation concept described here, and is science team leader. The content of the tell and ask modes is divided into a 'Pilot' Project and the Full Project. The Pilot Project is intended to test innovations in content, educational style, and technical design. It focuses on basic classification and tabular material, and a structured set of interactive explanations.

Search and Rescue Mission

Goddard Space Flight Center, Greenbelt, MD.

ADVANCED SEARCH AND RESCUE TECHNIQUES

W. A. Hembrook 301-286-8332

In accordance with the NASA commitment to the National Search and Rescue Plan, application of aerospace technology to supporting the search and rescue community will continue. Specifically, we will: (1) enhance the future effectiveness and scope of the SARSAT system; (2) develop and demonstrate airborne and space-based systems using remote sensing technology to assist search and rescue without the aid of emergency beacons; (3) develop near-instantaneous distress alerting using geosynchronous satellites; and (4) develop means for applying remote sensing and satellite communications technology in aiding disaster mitigation and recovery. The approach will be to: (1) develop improved SARSAT receiver-processor design with decreased susceptibility to interference; (2) develop and demonstrate prototype low-cost satellite-compatible beacons; (3) develop a synthetic aperture radar system and with it perform additional experiments to establish the range of conditions under which it is effective in detecting crashed aircraft under a forest canopy; (4) refine techniques for isolation of aircraft targets in radar imagery and perform user demonstrations; (5) characterize performance of GOES search and rescue ground station; and (6) support NASA efforts in demonstration of disaster mitigation techniques and systems.

Space Processing Science and Spacelab Payload Development

Marshall Space Flight Center, Huntsville, AL.

ELECTRONIC MATERIALS

Sándor L. Léhoczky 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 as follows: (1) to understand the role of gravity and determine limitations in Earth's gravity; (2) to determine and demonstrate advantages to be obtained by growing crystals in space; and (3) to 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) the 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.
and/or boundary and initial conditions (e.g., spherical droplets, negligible sedimentation); and (4) improving in-space system performance, principally spacecraft fire safety. After justifying the need for microgravity research, Principal Investigators from academia, industry, NASA, and other governmental agencies are chosen to develop analytical and theoretical models and supporting experiments—whenever possible—in ground-based laboratories. Experimental and theoretical results are then evaluated to determine if together they provide a satisfactory understanding of the combustion phenomena under study. It should be noted that in many cases, the low-gravity experiments reveal new and unexpected phenomena, so that rather than guiding the experiments, theoretical investigations may be instigated after experimental completion. When the test-time or gravity-level limitations of ground-based laboratories preclude conclusive experiments, the Principal Investigator defines additional experiments to be conducted in space-based laboratories. The Principal Investigator then performs supplemental analyses and experiments to develop the conceptual design of space-based hardware and select the desired test conditions for the eventual experiments. These studies are presented in a Science Requirements Document and a recommended conceptual design for the hardware which together summarize the justification and feasibility of the experiment. Participation by investigations in this RTOP is based primarily on competitive selection through NASA Research Announcements (NRA's); in FY-93, 14 of the 18 investigators supported by this RTOP received approval following their response to NRA-89-OSSA-22, Microgravity Combustion Science.

W93-70508 674-23-01
Lyndon B. Johnson Space Center, Houston, TX.

BIOTECHNOLOGY RESEARCH
G. F. Spaulding 713-483-2357

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 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 proposals for flight experiments, promote ground-based applications of these technologies, and refine the scientific background and justifications for proposed flight experiments.

W93-70509 674-23-08
Marshall Space Flight Center, Huntsville, AL.

BIOTECHNOLOGY
Robert S. Snyder 205-544-7755

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 determine possible advantages of the low-gravity environment for separation, purification, crystallization, and characterization of biomedical materials; design, develop, manufacture, and test experiment apparatus to conduct experiments in low gravity; apply ground/flight knowledge to the improvement of bioprocessing procedures on Earth; develop broad and strong collaborative interactions with research scientists; and identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity.

W93-70510 674-24-00
Langley Research Center, Hampton, VA.

FLUID PHYSICS
J. F. Creedon 804-864-6033

The objective of this research area is the ground based development of theory and techniques which will support microgravity science flight experiments. The approach is the development of mathematical models, fluid flow measurement techniques, and basic scientific knowledge which are applicable to microgravity science experiments.

W93-70511 674-24-05
Lewis Research Center, Cleveland, OH.

FLUID PHYSICS
Nancy J. Shaw 216-433-3285
(694-03-03; 694-22-00; 694-23-00; 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 significant fluids issues as possible is to concentrate on a much smaller set of reasonably self-contained research topics or areas of fundamental understanding. At LeRC the topics/areas of interest include the following: (1) Phase Transitions (first order and second order); (2) Multiphase Flow; (3) Magnetohydrodynamics; (4) Multiphase Flow; and (5) Capillary Phenomena. In general, idealized simple systems using reference fluids mean ambient temperatures are chosen for initial modeling and experimental work before proceeding to studies of more application specific configurations and conditions. Principal Investigators from academic institutions, industry, other Government agencies and NASA LeRC are currently involved in a variety of research focused on providing a foundation of fundamental understanding of low-gravity fluid behavior/phenomena. Emphasis in the early stages of the research programs is on analytical/numerical modeling and normal gravity laboratory tests to provide predictive capabilities. When possible, these efforts are followed by low-gravity testing in ground-based facilities to provide more specific data for further model refinement; while the relatively short low-gravity test time limits the data that can be obtained, in many cases a significant amount of valuable information can be acquired. This is particularly true when scaling analyses can be applied with confidence. When the capabilities of the ground-based low-gravity facilities are exhausted or found to be inappropriate, efforts then are directed toward the development of science requirements and conceptual designs for space flight experiments.

W93-70512 674-24-08
Marshall Space Flight Center, Huntsville, AL.

FLUID PHYSICS
Robert S. Snyder 205-544-7755
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. Experimental and theoretical work will be carried out to understand the electrokinetic properties of particulate suspensions and check the fundamental concepts of the physics of the equivalence principle. Other objectives are to develop a body of data on the conductivity and dielectric behavior of various particulate suspensions and develop a theory to describe how the dielectric constant and conductivity depend on the properties of the suspension, and to test the Einstein Equivalence Principle to a very high accuracy to check fundamental concepts of physics.

W93-70513 674-25-05
Lewis Research Center, Cleveland, OH.

METALS AND ALLOYS
Nancy J. Shaw 216-433-3285
(694-03-03; 694-22-00; 694-23-00; 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 dendritic solidification experiments, critical re-examination of published work to determine reasons for discrepancies between existing models and theories for dendritic and cellular growth, development of quantitative techniques for observing transparent crystal growth, evaluation of the potential of bulk undercooling as a microgravity process, and examination of the zone melting technique for application to advanced metallic materials.

W93-70514 674-25-05
Marshall Space Flight Center, Huntsville, AL.

METALS AND ALLOYS
Peter Curren 205-544-7783

Control of the solidification of metals and alloys is key to gravitational effects such as buoyancy-driven convection. Thus, the objectives of the study are to: identify various aspects of solidification phenomena that may be affected by gravity-driven flows; devise and conduct critical experiments in both increased gravity as well as in space; and 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 monotropic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

W93-70515 674-26-05
Lewis Research Center, Cleveland, OH.

GLASSES AND CERAMICS
Nancy J. Shaw 216-433-3285
(694-03-03; 694-22-00; 694-23-00; 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 AO proposal was submitted. Research involving order-disorder transitions of ceramic slips and agglomeration of ceramic powders has been sponsored. Though included in combustion science, there is some new work at the University of Colorado on self propagating thermal reactions for the preparation of continuous ceramic networks, metal filled composites. Ceramic powder agglomeration research has been tied in with laser light scattering development in the MMSL. A new effort in fiber growth has been initiated via an NRC fellow.

W93-70516 674-26-08
Marshall Space Flight Center, Huntsville, AL.

GLASSES AND CERAMICS
Edwin C. Ethridge 205-544-7767

The objectives of this activity are to perform studies that utilize the unique capabilities of space processing to investigate particular problems in the science and engineering of glasses and ceramics. These include the study of gravity dependent behavior in melts, the investigation of container induced heterogeneous nucleation effects, the examination of novel techniques and applications for containerless processing of glasses and ceramics, development of pseudo containerless processing methods for use with glasses and ceramics, and understanding and defining the limitations of processing in 1-g to support the development of meaningful flight experiments. The experiments can be grouped into two categories, fluids experiments and containerless processing experiments. Fluids experiments include the investigation of phenomena such as bubble motion, containerless viscosity and surface tension measurements, and inviscid fluid pulling experiments. The fluids class of experiments require low-g in order to minimize convection or hydrostatic flow. Containerless processing is the other important class of the glass and ceramic experiments. The difficulty in levitating and melting glasses and ceramics in 1-g has had a limiting effect on the development of the discipline.

W93-70517 674-27-05
Lewis Research Center, Cleveland, OH.

MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL)
Nancy J. Shaw 216-433-3285
(694-03-03; 694-22-00; 694-23-00; 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 contains a numerical analysis facility, the Computational Materials Laboratory, which addresses fluid flows in microgravity. It models microgravity experiments, apparatus, and equipment. It is staffed by a small group of engineers and technicians providing a varied background in materials, chemistry, computer science, mechanical engineering, and physics. Funding is required for support of the support service contractor technicians working in the lab, for purchase and maintenance of facilities, for supplies, and for operation of a metallurgical laboratory.

W93-70518 674-28-05
Lewis Research Center, Cleveland, OH.

GROUND EXPERIMENT OPERATIONS
Nancy J. Shaw 216-433-3285
(694-03-03; 694-22-00; 694-23-00; 694-24-00)

The objective of the activities funded under this RTOP is to provide the human resources, equipment, and facility support necessary to perform reduced gravity experiments in the 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 aircraft operations engineering support via a support service contract, engineering design through a university (Case Western Reserve) cooperative agreement, a variety of facility support hardware, components, and instrumentation, and composite rate charges for technician support.

W93-70519 674-26-08
Marshall Space Flight Center, Huntsville, AL.
GROUND EXPERIMENT OPERATIONS
Michael S. 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. 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.

W93-70520 674-29-08
Marshall Space Flight Center, Huntsville, AL.
CONSULTING AND PROGRAM SUPPORT
Robert S. Snyder  205-544-7755
The objectives of this RTOP are to provide the necessary scientific manpower to augment the implementation of the Microgravity Science and Applications (MSA) research and technology development effort, and 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. The Marshall Space Flight Center (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 the visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented with this documentation included in the NASA Headquarters data base for access to the scientific community, NASA Headquarters MSAD, and other NASA centers.

Sounding Rockets

W93-70521 879-10-00
Goddard Space Flight Center, Greenbelt, MD.
SPARTAN 201 WHITE LIGHT CORONAGRAPH
R. R. Fisher  301-286-5682
The SPARTAN 201 White Light Coronagraph is an externally occulted doublet objective system used to make out or eclipse measurements of the brightness distribution of the solar corona. The field of view extends from 2.0 to 6.0 solar radii, as measured from the center of the sun's disk. This system, which uses a charge coupled device for image formation, will be used to infer the distribution of electron density near the sun during the operation of its companion instrument, the Ultraviolet Coronal Spectrometer, a second instrument provided by the Smithsonian Astrophysical Observatory. Together these instruments will be operated from the same spacecraft to gather a complete set of diagnostic observations from which limits may be set on the coronal electron density distribution, the proton density distribution, the electron and proton temperature distributions, and the flow velocities associated with defining the nature of the solar plasma in the region of the solar atmosphere where it is believed the acceleration of the solar wind occurs.

W93-70522 879-11-38
Goddard Space Flight Center, Greenbelt, MD.
SOUNING ROCKET EXPERIMENTS
Roger Thomas  301-286-3756
The objectives of this RTOP are as follows: (1) to develop solar extreme ultraviolet (EUV) and soft x ray sounding rocket payloads for the purpose of characterizing the physical processes of energy transport and dissipation in the transition region and corona and their relationships to heating of the corona, acceleration of the solar wind, and energy release and dissipation during solar flares; (2) to calibrate, launch, and analyze data from sounding rocket payloads developed under this RTOP; and (3) to correlate flight results with ground-based observations and theoretical models. The approach is to develop instrumentation that can both characterize the spatial morphology of the coronal emission and determine its thermal and non-thermal velocity components via measurements of EUV emission line profiles over a wide range of transition region and coronal electron temperatures. Activities include definition, design, calibration, and flight of rocket-borne instrumentation, analysis of resulting data and correlation with co-temporal observations, comparison of results with predictions based on models of coronal heating, solar wind acceleration, and solar flares.

W93-70523 879-11-48
Goddard Space Flight Center, Greenbelt, MD.
PROPOSAL FOR A HIGH-ENERGY IMAGING DEVICE (HEIDI) ON A BALLOON
C. J. Crannell  301-286-5007
The High Energy Imaging Device, HEIDI, is in the hardware development phase of its program for observations of solar flares during the current solar maximum. The primary scientific objective to be pursued with HEIDI is to image solar flares in hard x rays and gamma rays. HEIDI is based on the technique of Fourier transform imaging and utilizes modulation grid collimator optics that ultimately will provide full-Sun imaging with 2-arcsecond resolution over the energy range from 20 to 700 keV at time resolutions from 0.1 to 2 s. For the first flight scheduled for September 1992, HEIDI will employ two rotating modulation collimators (RMCs), each composed of a matched pair of high-Z collimator grids separated by 5.2 m. The two subcollimators provide slit spacings corresponding to angular dimensions of 11 and 25 arcseconds FWHM which correspond to a 5 to 40 arcsecond range of measurable scale sizes. A 9 cm diameter x 1.5 cm thick NaI(T1) scintillation spectrometer will serve as the detector behind each RMC. The RMC's are mounted within a telescope canister that will be pointed to an accuracy of 0.1 degree. A canister mounted aspect system provides absolute fine pointing knowledge to 0.2 arcsecond every 20 ms. An adaptation of the LASER beam steering technique will enable off-SUN pointing with the solar aspect system for calibration of the hard x ray imaging system with non-solar sources. The instrument has an effective area of 30 sq cm and is designed for a one-day duration balloon flight at an altitude of 40 km or higher. The payload may be readily upgraded to 4 RMC's with an effective area of 130 sq cm.

Mission Operations and Data Analysis

W93-70524 889-59-00
Goddard Space Flight Center, Greenbelt, MD.
NEPTUNE DATA ANALYSIS
B. J. Conrath  301-286-6088
This RTOP supports advanced analysis and interpretation of data acquired by the Voyager 2 spacecraft during the Neptune
encounter. Task 1 consists of an investigation of the thermal structure, dynamics, and cloud properties of Neptune’s atmosphere. Data from the Voyager infrared spectroscopy experiment (IRIS) are used along with other Voyager and ground-based data. Task 2 is a study of the hydrocarbons in Neptune’s atmosphere. The primary data source to be used is that from Voyager IRIS. Task 3 consists of analyses of the Voyager 2 Plasma Science Experiment (PLS) electron observations in the vicinity of Neptune. Task 4 is a study of the plasma properties and dynamics of the magnetopause/cusp regions and compares Neptune phenomena with their terrestrial counterparts.

**NEPTUNE DATA ANALYSIS**

J. Cuzzi 415-604-6343

The major objectives of this RTOP are: (1) to search for lightning in the atmosphere, determine its latitude-longitude distribution, and determine the energy dissipation rate of lightning activity; (2) to determine the scattering properties of Neptune’s and Triton’s atmospheres; and (3) to constrain the structure and particle properties of the Neptunian ringmoon system. The approach is to analyze the images obtained by the Voyager 2 spacecraft specifically for these purposes and to conduct a parameter study with a theoretical model to determine the parameters needed to specify the scattering properties of the atmosphere.

**NEPTUNE DATA ANALYSIS PROGRAM**

J. D. Goguen 818-354-3943

This group of 15 research tasks addresses a range of data analysis and interpretation problems based on Voyager 2 observations at Neptune. Specifically, the science objectives encompass the use of radiative transfer models to investigate the planet’s atmospheric structure including the global energy balance, composition, temperature, and cloud properties, and the use of Voyager data sets to study Triton’s wind fields, Neptune’s rings, and to search for small satellites. Voyager PPS, IRIS, and imaging data and Earth-based observations are used to study surface characteristics of Triton including its thermal history, topographic relaxation, solid volatile transport, solid-state greenhouse processes, and spectral reflectance properties (geometric and Bond albedos, phase integrals, and photometric function versus wavelength). Data from radio occultation experiments were used to infer the helium-to-hydrogen abundance ratio in Neptune’s atmosphere. Radio science investigations are also used to improve our knowledge of Neptune’s gravitational field and ephemeris. The approach makes use of direct inversion algorithms to determine temperature from the infrared data and sophisticated radiative transfer/aerosol models to examine the solar reflection spectra. The best available ground-based and other spacecraft data are used together with the Voyager measurements to take advantage of the unique spatial, angular, and wavelength coverage available from the Voyager data. Algorithms are developed for creating maps of normal reflectances from Triton imaging data. This RTOP also includes extensive work on data archiving, cataloging, and dissemination.

**OFFICE OF SPACE COMMUNICATIONS**

**Advanced Systems**

W93-70527 310-10-23

Goddard Space Flight Center, Greenbelt, MD.

**SOFTWARE ENGINEERING TECHNOLOGY**

Frank McGarry 301-286-6846

The objective of this RTOP is to develop, evaluate, and refine software engineering technology to significantly and continuously improve the software development process in NASA. This is accomplished through the Software Engineering Laboratory (SEL), which measures and assesses software engineering technologies within the Flight Dynamics Division (FDD). The SEL measures all software produced by the FDD to support GSFC missions. Successful technologies are incorporated into the FDD software development process. The research process consists of the following steps: (1) characterize the FDD development environment through standard measurements; (2) identify a potentially beneficial technology; (3) identify any new measures needed to understand and assess the new technology; (4) apply the new technology to production projects; (5) compare measures for the new technology to the baseline characteristics; and (6) package successful technologies into development guidelines and training.

**FLIGHT DYNAMICS TECHNOLOGY**

Ken Galal 301-286-9218

The objective of this RTOP is to develop, evaluate, and demonstrate new technology for flight dynamics in the TDRSS, STS, and SSF era, encompassing algorithms, techniques, software, and system configurations pertaining to attitude and orbit determination/prediction/analysis for both ground-based and onboard applications. Technological advancements in these areas will be aimed at increasing automation and improving accuracy and capability. 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.

**ASTROMETRIC DEVELOPMENT TECHNOLOGY**

R. P. Linfield 818-354-2806 (310-10-63)

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 to support spacecraft 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 reduce their impact on the final navigation observables. Deep-space navigation is limited by uncertainties in the measurement of components of spacecraft position and velocity in the plane of the sky. Thus a major thrust is the refinement of methods of spacecraft angular measurement using various astrometric techniques, primarily Very Long Baseline Interferometry (VLBI). The accuracy of relative astrometric measurements (across 1 radian or less of the sky) are currently limited by two error sources: fluctuations in tropospheric refractivity (primarily those due to water vapor) and system noise. The former of these two sources will be much more difficult to solve. Thus, in the near term, we will focus a large effort on techniques to reduce the contribution of the troposphere to our error budget. We will also continue an effort to drastically reduce system noise as an error source. 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 VLBI measurements of planetary orbiters. Evaluation of optical tracking techniques will determine their potential for application to future laser-equipped spacecraft. Both filled-aperture and interferometric devices will be considered. The instruments and errors will be studied, in order to optimize the ultimate performance of the technique. The current focus is on data and error analysis for filled aperture telescopes and design compatibility for the Deep
Space Optical Reception Antenna (DSORA) telescope that is being developed in another RTOP.

W93-70530 310-10-61
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS-BASED DSN CALIBRATION SYSTEM
Stephen M. Lichten 818-354-1614
(310-10-60; 310-10-63)
This RTOP develops and demonstrates the use of the Global Positioning System (GPS) to improve the tracking accuracy and efficiency of the Deep Space Network (DSN) by providing precise Earth platform and media calibration. The calibrations include Earth orientation parameters, tropospheric path delays, DSN clock synchronization and clock frequency offsets, and geometric DSN coordinates. Variations in Earth rotation, troposphere delays, and clock parameters can be determined with GPS data with better than sub-hourly resolution, thus allowing for their measurement simultaneously with deep space tracking scans. This simultaneity is generally not available with current non-GPS techniques, especially for calibrations which presently require observations of quasars with the DSN antennas. The use of GPS data for these calibrations will significantly increase the percentage of DSN resources available for deep space tracking and telemetry, while at the same time reducing the amount of DSN antenna time which must be allocated to non-spacecraft measurements such as support and calibration measurements on other sources. The data reduction for these calibrations will also be substantially simplified. This RTOP includes the following: system design; performance analysis; error analysis and parameter estimation software development; study and demonstrations of the use of GPS for DSN calibrations and mission support; and demonstrations of high precision tracking techniques on the GPS satellites and on future earth orbiters. The processing of GPS field data in the system demonstrations carried out in this RTOP utilizes the GPS software also developed under this RTOP. In FY-93, the major focus will be on refining GPS techniques and parameter estimate accuracy, and the exercising and testing of a prototype GPS-based DSN calibrations system.

W93-70531 310-10-62
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FREQUENCY AND TIMING RESEARCH
G. John Dick 818-354-6393
(310-10-60; 310-20-64; 310-20-66)
The general objective of this RTOP is to support Deep Space Network (DSN) needs for research in frequency and time generation, distribution, and characterization. A more immediate goal is to advance the art of various technologies being developed to meet the requirements of new missions, e.g., Ka band radio science, and to develop them to a stage where they can be transferred to implementation. The near term work is focused on the following: (1) the development of a DSN capability, from the linear ion trapped frequency source (LIT), for stability of parts in 10^16 at averaging intervals 100 is less than or equal to tau is less than or equal to 10,000 seconds; (2) development of the superconducting cavity maser oscillator (SCMO) for parts in 10^16 at averaging intervals 1 less than or equal to tau is less than or equal to 1000 seconds, and generation of spectrally pure signals at 8.1 and 32 GHz frequencies with the sapphire dielectric resonator oscillator; and (3) the distribution of frequencies and wide-band signals at X- and Ka-band with stability of parts in 10^16 through the development of fiber-optics systems. The emphasis this year for the trapped ion work is on performance improvement for the newly developed LIT technology and to make this technology more field-worthy. Also, advanced concepts which make possible a greater than or equal to 1 photon/atom signal recovery rate will continue to be pursued for both Mercury and Yuttembur. For the SCMO the emphasis will be on a field-worthy cryogenic configuration and on L.O. capability for improved LIT performance. Our third, and final, focus is on a field demonstration of frequency reference signal transmission capability at Ka-band.

W93-70532 310-10-63
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE SYSTEMS AND NAVIGATION TECHNOLOGY
Sam W. Thurman 818-354-0976
(310-10-50; 310-10-61; 310-20-67)
The overall objectives of this RTOP are as follows: (1) to increase the accuracy of the end-to-end Deep Space Network (DSN)-based navigation process; (2) to increase the efficiency, reliability, and flexibility of this process; (3) to shape the evolution of DSN-based navigation capabilities to meet future mission needs; and to help flight projects shape their mission plans to effectively utilize anticipated future DSN capabilities. To fulfill these goals, this RTOP formulates and develops new and improved ground-based radio and optical navigation systems and techniques, and navigation data processing systems. In the near-term (FY-93 and FY-94), the objectives of the RTOP are as follows: (1) develop and demonstrate a medium-to-high accuracy (300 to 30 nrd in an angular sense) radio navigation capability that minimizes resource requirements on both flight projects and the DSN; (2) provide system-level requirements analysis, guidance, and applications demonstrations for the development of future ground-based optical navigation systems; and (3) develop and demonstrate graphical user interface for orbit determination software systems and prototype software to automate radio metric data processing functions. Within the RTOP, radio navigation techniques are developed for relatively traditional mission types, such as planetary flybys, and for difficult new mission types, such as outer-planet orbiters that execute multiple satellite encounters. Whenever possible, demonstrations of new/improved techniques are performed using actual data from current missions. Navigation accuracies, factors limiting achievable accuracy, and DSN resource utilization required when using various data types for navigation are evaluated in a variety of representative mission scenarios, by means of numerical and analytical studies. Investigations of the navigational benefits of improved error source models and calibration methods are also performed. New navigation concepts for future spacecraft that may use optical communication links are developed, and when possible demonstrations of new technologies and observing techniques are conducted, using stars and natural solar system bodies (asteroids, natural satellites of the planets). The RTOP also endeavors to develop and demonstrate navigation data processing concepts and systems, such as the use of graphical user interfaces to increase the efficiency, flexibility, and reliability of DSN multi-mission navigation and flight project navigation operations; these concepts serve to reduce the cost of navigation-related operations and to maximize the productivity of navigation operations personnel.

W93-70533 310-20-35
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL COMMUNICATIONS
Michael A. Kainan 301-286-2646
Free space intersatellite optical communications systems are a new technology which can provide the high data rates required for the NASA Tracking and Data Relay Satellite System (TDRSS) network and beyond. Optical communications offers a small size, light weight, low power, and low cost alternative to present microwave satellite systems. Two additional advantages from the use of the optical frequencies are the following: (1) immunity to RF interference; and (2) little competition for frequency allocation. The goal of this RTOP is to develop optical communications technology as an improvement to the microwave technology. The near term focus of this RTOP is the development of a Low Earth Orbit (LEO) optical terminal for future Geosynchronous Earth Orbit (GEO)-LEO space communications users. The LEO-GEO links would be from optical terminals on space vehicles or platforms (LEO) to optical terminals on the (GEO) TDRSS 2 system. There are two tasks on this RTOP: (1) the development of a prototype LEO terminal; and (2) the development of a low cost satellite optical communications experiment. The LEO terminal consists of a four inch diameter gimbaled telescope, gimbal controller electronics, IBM PC experiment controller, laser, receiver, interface optics, and mechanical structure. Integration of the LEO terminal
will begin in the 3rd and 4th quarters of FY-92. The integration of
the LEO terminal will be complete by early FY-93. The FY-93
RTOP will concentrate on the demonstration and testing of the
LEO terminal. A laboratory laser cross link will be established
using bench top components and the LEO terminal. The experiment
consists of establishing a 50 Mbps optical communications link
from earth to LEO satellite to earth. The LEO satellite has an
attached optical corner cube retroreflector. The FY-93 RTOP will
concentrate on the development of a detailed numerical model of
this experiment.

W93-70534  310-20-36
Goddard Space Flight Center, Greenbelt, MD.
PLANNING AND SCHEDULING SYSTEMS TECHNOLOGY
Karen L. Moe  301-286-5998
The goal of this RTOP is to identify and explore approaches
for developing more responsive and more automated planning and
scheduling systems for Mission Operations and Data Systems
Directorate (MO&DS). Major objectives are as follows: (1) to
identify and evaluate operations concepts from an end-to-end
perspective (i.e., from the science user's workstation to the mission
spacecraft), addressing system architecture and interface issues;
(2) to evaluate technology alternatives including expert systems,
online research and polynomial algorithm techniques, system
engineering and human factors, and evaluate existing tools with
respect to performance factors and applicability to MO&DS
scheduling problems; (3) to propose a generic planning and
scheduling tool set environment for addressing future system
requirements; and (4) to develop a planning and scheduling
technology testbed for prototyping and demonstrating concepts
and tools. This is a system-level RTOP supporting planning and
scheduling functions in mission operations, mission support
computing, and space network operations.

W93-70535  310-20-37
Goddard Space Flight Center, Greenbelt, MD.
COMMUNICATIONS AND TELEMETRY
Warner H. Miller  301-286-8186
The objective of this RTOP is to investigate advanced
communications systems including: (1) the hardware design of
coded transmission systems that are usable in the NASA
environment, (2) the theoretical analysis of bandwidth-efficient
coded transmission systems, and (3) the transport technology that
can be used to support multi-media data from space to ground in
a packet mode. The approach for this RTOP is to perform studies,
analyses, simulation and the proof-of-concept implementations of
advanced communications systems.

W93-70536  310-20-38
Goddard Space Flight Center, Greenbelt, MD.
NETWORKS COMMUNICATION TECHNOLOGY
T. E. Butler  301-286-7335
The objective of this RTOP is to continue the development of
a NASA Communications (Nascom) Open Systems
Interconnections (OSI) Protocol (NOSIP) test bed to investigate
techniques for interfacing with OSI networks. The objective is being
pursued under an OSI protocols task. This task involves analyzing
and assessing the relevant merits of OSI network technology for
application in Nascom networks. The approach for this RTOP is
to investigate areas that can provide the maximum benefits to the
Division, Directorate, Center, and NASA. The OSI protocols task
is structured as a three year effort. Analyses, testing, integration,
and prototype development. Software development is included.
The RTOP effort on this task will culminate in a report, software
package, or prototype equipment. Follow-on development work, if
any, will use research and development funds.

W93-70537  310-20-46
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED SPACE SYSTEMS FOR USERS OF NASA
NETWORKS
R. P. Hockensmith  301-286-9067
The objective of the work under this RTOP is to achieve
unprecedented 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 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) develop the basic operational space flight
requirements; (2) investigate active and passive components and
antenna systems; (3) investigate methods for reducing and
controlling torque noise induced for the pointing of large high-
gain antennas; (4) investigate methods of high density and high-
rate recording storage and playback; (5) investigate improvements
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.

W93-70538  310-20-64
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TRANSMITTER SYSTEMS DEVELOPMENT
Rob Hartop  818-354-3433
(310-20-65; 310-20-69)
The objective of this RTOP is the design, development and
construction of advanced transmitters that will enhance
performance, reduce costs, and improve the reliability of the Deep
Space Network transmitter facilities 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-band (7.2 GHz) or Ka-band (34 GHz)
is in progress. This transmitter system will feature advanced
technology in several areas, including those that are required for
very high phase stability and high reliability, and complete
microprocessor monitoring and control. The resulting transmitter
system will be applicable to many NASA anticipated
requirements including support for future robotic and manned
missions to the Moon and Mars. The focus of this work in FY-93
is the development of a lower power Ka-band transmitter suitable
for a beam waveguide antenna. Techniques will be developed for
combining multiple high power sources while receiving multiple
frequencies in an efficient and versatile manner, including beam
waveguide antenna environments. Advanced dichroic plates of new
design are being developed for frequency separation and
simultaneous operation, including up- and downlinks in the same
and different frequency bands. A new feed system that will
provide simultaneous X- and Ka-band reception will be initiated
in FY-93, with an eventual goal of adding X-band uplink as well.

W93-70539  310-20-65
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTENNA SYSTEMS DEVELOPMENT
Michael A. Thorburn  818-354-1843
(310-20-64; 310-20-69; 310-20-70)
The role of this RTOP is to develop electromagnetic,
servo-control, structural, and mechanical technology to increase
the capabilities of the large antennas in the Deep Space Network
(DSN) for mission support. The focus of the current activities is
the new 34-meter beam waveguide antenna, DSS-13, which is the
forerunner for the next several antennas to be built in the
DSN. Present objectives are to develop multiple frequency band
antenna capabilities at DSS-13 over 1 to 45 GHz including
simultaneous dual-frequency and uplink/downlink operations for
spacecraft missions; to achieve high accuracy and stable radio
frequency (RF) beam pointing at 32 GHz, and to improve effective
antenna gain at 32 GHz. In addition, recently, extending the
lifetime of the 70-meter antennas in the DSN by improving
operational reliability and availability has been of considerable
interest. To meet these stated objectives, technologies such as
mechanical actuation of surfaces and electromagnetic pointing of

the antennas are being developed. To support these developments, the antenna-structural and antenna-electromagnetic analysis, synthesis, and measurement techniques are being improved. Antenna system-level studies are done to prioritize the technologies developed for successful and cost-effective transition to DSN implementation.

W93-70540 310-20-66
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

RADIO SYSTEMS DEVELOPMENT
J. Bautista 818-354-6994
(310-20-65; 310-20-64; 310-20-70; 310-20-60)

The objectives of this RTOP are to develop and demonstrate low-noise amplifier technology that will lead to ground-based improvements in spacecraft communications and navigation for deep space missions. The improvements sought are lower noise temperatures, increased bandwidths, reduced implementation costs, and increased reliability of receiving equipment and cryogenic (cooling) systems. These improvements address both present and future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications downlink is the gain of the receiving antenna divided by the system noise temperature (G/T). This RTOP addresses the challenge of keeping the system noise temperature as low as technology economically permits over the present and future DSN frequency band. The immediate concern of this RTOP is the development of broadband, high gain, low-noise amplifiers at 32.00 and 33.68 GHz which are compatible with the DSN and Ka-band link experiment (KABLE) frequencies. These amplifiers will be compact, economical and compatible with beam waveguide antenna 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. In FY-93, MASER’S and HEMT’S will be demonstrated to have noise temperatures below 4 K and 9 K (referred to the amplifier input), respectively. In addition, to protect HEMT’S from radio frequency interference (RFI), filters utilizing high temperature superconductors will continue to be developed. The analytical tools and measurement systems needed to characterize the associated materials and devices for the design of practical amplifiers are continuing to be developed. There is also a continuing effort to develop a more reliable 1.6 K cooling system appropriate for use on antennas with beam waveguide feed systems to greatly improve maser performance. For example, on cooling an 8.4 GHz maser from 4.5 K to 1.6 K the gain in dB increases three times while the noise temperature is reduced by a factor of three.

W93-70541 310-20-67
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT
James R. LeSh 818-354-2766
(310-19-33; 310-20-60; 506-72-31; 315-91-60)

The objective of this RTOP is to develop and demonstrate reliable and efficient optical communications and tracking capability for use with Deep Space Network (DSN) supported missions of the future. The work will concentrate on the definition, design, development, and analysis of communications and tracking systems that could support such missions, and will include the development of high-leverage technologies that have a major influence on the character of those systems. 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 appropriate justification, flight-ground architectural needs, and 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. However, studies indicate that even ground-based optical systems could provide communications and tracking performance that exceeds current DSN capabilities by at least 10 dB. Accordingly, this RTOP will focus initially on 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 activities for the RTOP during FY-93 are the definition and planning for a ground-based research and development facility, establishment of a network of three autonomous atmospheric visibility monitoring (AVM) telescopes for the formulation and validation of an atmospheric weather model, and definition of an interim ground terminal for supporting near-term space demonstrations of optical communication technology.

W93-70542 310-30-69
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DSS 13 INSTRUMENTATION AND CAPABILITIES
Mark Gatti 818-354-2123
(310-20-66; 310-10-62; 310-20-65; 310-30-71; 310-10-60; 310-20-64; 310-30-70)

The objective of this RTOP is to provide the core equipment and capabilities for the Deep Space Network research and development station (DSS 13) 34-meter beam waveguide antenna. This equipment must support a multiplicity of users both internal and external to the Advanced Systems Program. It is important to support these user activities since many of these activities are precursors to future DSN capabilities, enhancements, and innovative efficiencies. Hence a critical element of this RTOP is the demonstration of new and emerging antenna, receiver and station technologies, particularly as they apply to the new 32 GHz downlink DSN frequency band (Ka-band). General objectives include providing for antenna calibrations, water vapor radiometers, low noise amplifiers, digital receivers, feeds and front-ends, and monitor and control. Certain capabilities, of interest only to single users, will be provided by those users. At the end of such a research program, an agreement may be reached whereby this new capability is absorbed into the core facility of DSS 13 and support for the capability is continued. Also, there is a work unit which will provide engineering support to users, and to the station personnel in the event of component failure. Core capabilities will be implemented in a timely manner consistent with the future goals for the anticipated use of the facility. The major near-term objectives are to provide simultaneous 2.3/8.5 GHz (S/X-band) receive for Very Long Baseline Interferometry (VLBI) and radar, and the plan to decommission the existing 26-meter antenna. The core capabilities include the S/X-band receive strings, K/Ka-band receive strings, precision pointing, and monitor and control. The core capabilities to be provided by this RTOP will be realized through the close cooperation and careful coordination of the efforts of related RTOPs, and by anticipating the future needs of the facility. In this way the new technologies to be used in the DSN may be sufficiently tested in a well supported research and development environment.

W93-70543 310-30-70
Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NETWORK SIGNAL PROCESSING
Sami Hamedi 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 of the RTOP are: (1) develop and demonstrate signal processing techniques and algorithms for a Ka-band array feed in order to reduce gravity-induced antenna gain losses; (2) develop and demonstrate techniques for generating array feed error signals to provide electronic antenna pointing capability at Ka-band; (3) develop and demonstrate a telemetry arraying system that is capable of performing various combining techniques on recorded spacecraft data; (4) develop high-speed sampling and digitizing circuits to enable wider bandwidth front-end digital signal processing; (5) develop custom Very Large Scale Integrated (VLSI) circuits for
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 modeling, and artificial intelligence (AI) to human/machine interface and interaction problems in order to realize the desired improvements. The approach to be followed in realizing the objectives is to provide tools and environments to support the evaluation, and use of operational interfaces. The evaluation will be supported by a tool designed to provide guideline-based evaluations of human/computer interfaces. Intelligent Tutoring Systems will provide training to both managers and technicians in the proper use of their respective systems. A systematic evaluation of operational graphical interfaces will be carried out as part of a major technology transfer process. This RTOP is a system level RTOP on mission operations, mission support computing, and general systems engineering activities.
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 Level Zero Positioning (LZP) systems. These systems require the use of commercially available disk farms 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 LZP system architectures adaptable to a range of mission data rates.

W93-70549 310-40-49
JPL, California Inst. of Tech., Pasadena.
ADVANCED ENVIRONMENTS FOR SOFTWARE AND SYSTEM DEVELOPMENT
Sylvia B. Sheppard 301-286-5049
The goal of this RTOP is to develop and evaluate systems-level concepts and technologies that will be used to optimize the development, operation, management and evolution of Mission Operations and Data Systems Directorate (MO&DSD) data systems. Major objectives 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 the use (and reuse) of data system modeling, and (2) the definition and phased prototyping of an advanced software engineering environment. The 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 systems-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite System (TDRSS) operations.

W93-70550 310-40-51
JPL, California Inst. of Tech., Pasadena.
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.

W93-70551 310-40-73
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSN DATA PROCESSING AND PRODUCTIVITY
Lynne P. Cooper 818-306-6145 (310-30-69)
The objective of this RTOP is to develop and demonstrate advanced computer information processing technologies to improve the capability of the Deep Space Network (DSN) to meet user needs, including: (1) increasing the availability of the DSN to support increased mission sets; (2) reducing system development costs and risk; (3) increasing the predictability, reliability, and efficiency of service; (4) increasing the overall ease of operating the DSN; and (5) improving performance and security of end-to-end data delivery. The work units in this RTOP fall into two basic areas. (1) Operability, Automation, and Support: In this area, advanced information processing technologies are applied to improve the way that the DSN currently operates. Work units address automation of monitor and control functions, and the extensibility of Knowledge-Based Systems (KBS) to meet the full scope of operational needs, including embedded training, automated scheduling, and subsystem automation guidelines. (2) DSN End-to-End Architecture: The overall data delivery capability of the DSN is dependent upon efficient high speed data processing, transfer, and storage. Work units in this area address the evaluation, adaptation, and adoption of Open Systems Interconnect (OSI) and other standards for communications and storage, end-to-end architectural evaluation, Wide Area Networking technology, and high speed telemetry support. Two other work units, Data Flow Simulation and Software Engineering Project Management Simulation, are in the process of technology transfer. These work units are completing calibration and validation phases prior to being turned over to user organizations.
SUBJECT INDEX

ELECTRON SCATTERING
Theoretical Studies of Active Galaxies and Quas-Stellar Objects (OSOs) 188-46-01 W93-70204

ELECTRON TRANSITIONS
Theory, Laboratory and Data Analysis for Solar Physics 170-38-53 W93-70180
Submillimeter Astronomy W93-70194

ELECTRON-POSITRON PAIRS
Theoretical Studies of Active Galaxies and Quas-Stellar Objects (OSOs) 188-46-01 W93-70204

ELECTRONIC EQUIPMENT
Electronic Materials 674-21-05 W93-70505

ELECTRONICS
Stratospheric Observatory for Infrared Astronomy (SOFIA) 188-78-60 W93-70216

ELECTROMAGNETIC COUPLING
Properties of interstellar PAH's 189-44-57 W93-70202
Emergences of Interstellar Clouds 399-20-00 W93-70257
Role of Air-Sea Exchanges and Ocean Circulation (Computing) 428-81-10 W93-70263
Global Assessment of Active Volcanism 428-81-94 W93-70269
Role of Air-Sea Exchanges and Ocean Circulation (Sience) 429-81-10 W93-70277
Eos Science 429-81-38 W93-70281
Global Assessment of Active Volcanism 429-81-94 W93-70285
GEOEX Program Support 461-50-00 W93-70384
Lower Stratosphere Aircraft Data Analysis 464-34-00 W93-70424
Experimental Cloud Analysis Techniques 578-12-01 W93-70441
Neptune Data Analysis Program 889-59-00 W93-70526
ENERGY CONVERSION
Space Energy Conversion Research and Technology 506-41-00 W93-70067
Space Energy Conversion Research and Technology 506-41-00 W93-70068
Space Energy Conversion Research and Technology 506-41-00 W93-70069
Space Energy Conversion Research and Technology 506-41-00 W93-70070
Space Energy Conversion Research and Technology 506-41-00 W93-70071
Theory, Laboratory and Data Analysis for Solar Physics 170-38-53 W93-70180

ENERGY DISSIPATION
Photoprocesses/Spectroscopies of Astrophysical Molecules and Radicals 506-41-00 W93-70071
Laser Induced Fluorescence: A Technique for Remote Assessment of Photosynthetic Efficiency and Detection of Environmental Stress 462-31-63 W93-70339

ENERGY LEVELS
Cosmic and Heliospheric Physics 170-10-10 W93-70176
High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies 188-46-01 W93-70205
Thermosphere-Ionosphere-Mesosphere-Magnetospheric Interactions 432-48-00 W93-70294

ENVIROMENT MODELS
Biogeochemical Cycling Research on the Oregon Transact 462-43-00 W93-70344

I-23
SUBJECT INDEX

Two-Dimensional Stratrophic Chemical Model - Radiation, 570-23-01, W93-70451
Fluid Physics, 674-24-08, W93-70512

HEAT TRANSFER COEFFICIENTS In-Space Experiments, 506-74-00, W93-70105
Evolution of Volcanic Terrians, 465-44-02, W93-70412

HEAVY ELEMENTS Planetary Material Surface and Exposure Studies, 152-17-40, W93-70147

HEAVY IONS Space Radiation Effects and Protection (Environmental Health), 199-04-00, W93-70225
Radiation Health, 199-04-11, W93-70226

HEAVY LIFT LAUNCH VEHICLES Earth-To-Orbit Transportation, 584-03-00, W93-70119

HELICOTER PROPELLER DRIVE Propulsion and Power Research and Technology, 505-62-00, W93-70004

HELICOTERS Aerodynamic Research and Technology, 505-59-00, W93-70001

HELIOSPHERE Cosmic and Heliospheric Physics, 170-10-10, W93-70116
Cosmic and Heliospheric Physics, 170-10-10, W93-70117

HELIUM Advanced Magnetometer, 495-51-01, W93-70404

HERING-HARO OBJECTS Center for Star Formation Studies, 399-20-01, W93-70260

HETEROODYING Science Sensing (Remote), 582-03-00, W93-70110
Science Sensing (Remote), 582-03-00, W93-70111
Science Sensing (Remote), 582-03-00, W93-70112
Spatial and Physical Properties of Planetary Atmospheric Constituents, 154-50-00, W93-70155
Submillimeter Astronomy, 189-44-23, W93-70194
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar, 188-44-24, W93-70197
NDSC Microwave Instrument Support, 464-13-00, W93-70260

HETEROGENITY Homogeneous and Heterogeneous Processes of Atmospheric Interest, 464-21-05, W93-70377
Theoretical Investigation of Stratrophic Particles, 579-22-00, W93-70350
Glass and Ceramics, 506-43-00, W93-70076

HIGH ALTITUDE Science Sensing (Remote), 537-01-00, W93-70149
Atmospheric Effects, 537-01-00, W93-70149
Ozone Measurements, 537-01-00, W93-70149

HIGH ALTITUDE BALLOONS Gamma-Ray Spectroscopy, 189-44-23, W93-70194

HIGH ALTITUDE MOBILITY TRANSISTORS Radios Systems Development, 310-20-66, W93-70540

HIGH ENERGY INTERACTIONS High Energy Astrophysics International Programs, 463-82-09, W93-70299

HIGH FREQUENCIES Antenna Systems Development, 310-20-66, W93-70539

HIGH GAIN Advanced Space Systems for Users of NASA Networks, 310-20-66, W93-70537
Radio Systems Development, 310-20-66, W93-70540

HIGH LEVEL LANGUAGES Construction of an Advanced Software Tool for Planetary Atmospheric Modeling, 656-85-24, W93-70494

HIGH PRESSURE GA-Compressor Engine Technology, 535-05-00, W93-70046

Space Energy Conversion Research and Technology, 506-41-00, W93-70067
Materials and Structures Research and Technology, 506-43-00, W93-70076
Space Transportation, 584-04-00, W93-70123

HIGH RESOLUTION Science Sensing (Remote), 592-03-00, W93-70111
Mars Ladar (Lidar from the Mars Surface and Mars Orbit for Atmospheric Studies), 157-03-90, W93-70173
Cosmic and Heliospheric Physics, 170-10-10, W93-70117
Deep Optical/UV Imaging of Quasars Below the Lyman Limit, 188-41-21, W93-70183
Optical/UV Laboratory Astrophysics, 188-41-57, W93-70191
Laboratory Astrophysics, 188-44-57, W93-70203
Gamma-Ray Spectroscopy, 188-45-58, W93-70208

HIGH THROUGHPUT X-Ray Spectroscopy, 188-46-59, W93-70210
Integral Mission Definition Study, 188-78-01, W93-70211
Ground-Based Infrared Astronomy, 196-41-50, W93-70218
Advanced Infrared Astronomy, 196-41-54, W93-70220
Automated Geophysical Processor Development for the Alaska SAR Facility, 428-82-11, W93-70273
Global Assessment of Active Vovcanism, 429-81-94, W93-70285
Foreign Visitor Support, 429-97-04, W93-70286
Ice Sheet Geophysical Investigations Using Imaging Radar, 461-66-18, W93-70300

HIGH THRUST Propulsion Research and Technology, 506-43-00, W93-70540

HIGHER Altitude Research and Technology, 506-42-00, W93-70067
High Performance Flight Research, 506-43-00, W93-70076
Space Exploration, 584-04-00, W93-70123

HIGHER ALTITUDE BALLOONS Gamma-Ray Spectroscopy, 189-44-23, W93-70194

HIGH ELECTRON MOBILITY TRANSISTORS Radios Systems Development, 310-20-66, W93-70540

HIGH ENERGY INTERACTIONS High Energy Astrophysics International Programs, 463-82-09, W93-70299

HIGH FREQUENCIES Antenna Systems Development, 310-20-66, W93-70539

HIGH GAIN Advanced Space Systems for Users of NASA Networks, 310-20-66, W93-70537
Radio Systems Development, 310-20-66, W93-70540

HIGH LEVEL LANGUAGES Construction of an Advanced Software Tool for Planetary Atmospheric Modeling, 656-85-24, W93-70494

HIGH PRESSURE GA-Compressor Engine Technology, 535-05-00, W93-70046
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INFRARED DETECTORS</strong></td>
</tr>
<tr>
<td>Energetics of Interstellar Clouds</td>
</tr>
<tr>
<td>IPAC Astrophysics Data System (ADS) Support</td>
</tr>
<tr>
<td>Infrared Studies of Planetary Debris Around Young Main Sequence Stars</td>
</tr>
<tr>
<td><strong>INFRARED DETECTORS</strong></td>
</tr>
<tr>
<td>Information and Controls Research and Technology</td>
</tr>
<tr>
<td>506-59-00</td>
</tr>
<tr>
<td>In-Space Technology Experiments</td>
</tr>
<tr>
<td>Science Sensing (Remote)</td>
</tr>
<tr>
<td>Observatory Systems</td>
</tr>
<tr>
<td>Imaging Spectropolarimeter</td>
</tr>
<tr>
<td>Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers</td>
</tr>
<tr>
<td>IR Remote Sensing of SST</td>
</tr>
<tr>
<td>Thermal Infrared Science Support</td>
</tr>
<tr>
<td><strong>INFRARED IMAGERY</strong></td>
</tr>
<tr>
<td>Space Data Systems</td>
</tr>
<tr>
<td>Development of 1036 GHz Receiver for Astronomy and Near IR imaging at Palomar</td>
</tr>
<tr>
<td>Remote Sensing of Active and Recently Active Volcanic Features</td>
</tr>
<tr>
<td><strong>INFRARED INSTRUMENTS</strong></td>
</tr>
<tr>
<td>Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument</td>
</tr>
<tr>
<td>Global Assessment of Active Volcanism</td>
</tr>
<tr>
<td>Studies of Volcanic SO2</td>
</tr>
<tr>
<td>Global Assessment of Active Volcanism</td>
</tr>
<tr>
<td>Studies of Volcanic SO2, Theory</td>
</tr>
<tr>
<td>Experimental Cloud Analysis Techniques</td>
</tr>
<tr>
<td>Meteorological Parameters Extraction</td>
</tr>
<tr>
<td>Atmospheric Parameter Mapping</td>
</tr>
<tr>
<td>Outgoing Spectral Radiance: A Climatic Diagnostic</td>
</tr>
<tr>
<td><strong>INFRARED INTERFEROMETERS</strong></td>
</tr>
<tr>
<td>Spectral and Physical Properties of Planetary Atmospheric Constituents</td>
</tr>
<tr>
<td>Global Tectonic Motions</td>
</tr>
<tr>
<td>Outgoing Spectral Radiance: A Climatic Diagnostic</td>
</tr>
<tr>
<td><strong>INFRARED LASERS</strong></td>
</tr>
<tr>
<td>Laser Infrared Spectroscopy</td>
</tr>
<tr>
<td>Advanced Magnetometer</td>
</tr>
<tr>
<td><strong>INFRARED RADAR</strong></td>
</tr>
<tr>
<td>CO2 Lidar Backscatter Experiment</td>
</tr>
<tr>
<td>Lidar Target Calibration Facility</td>
</tr>
<tr>
<td>Atmospheric Backscatter Experiment</td>
</tr>
<tr>
<td><strong>INFRARED RADIATION</strong></td>
</tr>
<tr>
<td>Space High Research and Technology</td>
</tr>
<tr>
<td>Information and Controls Research and Technology</td>
</tr>
<tr>
<td>Science Sensing (Remote)</td>
</tr>
<tr>
<td>Dynamics of Planetary Atmospheres</td>
</tr>
<tr>
<td>Mars 3-D Global Circulation Model</td>
</tr>
<tr>
<td>Research Computing Facility and Cataloging for Infrared</td>
</tr>
<tr>
<td>Infrared and Radio Astrophysics Technical Development: Ground-Based Astronomical Instrument</td>
</tr>
<tr>
<td><strong>INFRARED RADIOMETERS</strong></td>
</tr>
<tr>
<td>Wind Measurement Assessment</td>
</tr>
<tr>
<td><strong>INFRARED SCANNERS</strong></td>
</tr>
<tr>
<td>Variations of Soil Moisture and Other Surface Parameters</td>
</tr>
<tr>
<td>Meteorological Parameters Extraction</td>
</tr>
<tr>
<td><strong>INFRARED SPECTROMETERS</strong></td>
</tr>
<tr>
<td>Space Data Systems</td>
</tr>
<tr>
<td>Information and Controls Research and Technology</td>
</tr>
<tr>
<td>Science Sensing (Remote)</td>
</tr>
<tr>
<td>Observatory Systems</td>
</tr>
<tr>
<td>Imaging Spectropolarimeter</td>
</tr>
<tr>
<td>Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor Bolometers</td>
</tr>
<tr>
<td><strong>INFRARED SPECTROSCOPY</strong></td>
</tr>
<tr>
<td>Airborne IR Spectrometry</td>
</tr>
<tr>
<td>Chemical Kinetics of the Stratosphere</td>
</tr>
<tr>
<td>Kinetics of Atmospheric and Stratospheric Reactions</td>
</tr>
<tr>
<td>Quantitative Infrared Spectroscopy of Minor Components of the Earth's Stratosphere</td>
</tr>
<tr>
<td>Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements</td>
</tr>
<tr>
<td>Laser Laboratory Spectroscopy</td>
</tr>
<tr>
<td>Kinetic Studies of Tropospheric Free Radicals</td>
</tr>
<tr>
<td><strong>INFRARED STARS</strong></td>
</tr>
<tr>
<td>Infrared Studies of Planetary Debris Around Young Main Sequence Stars</td>
</tr>
<tr>
<td><strong>INFRARED TELESCOPES</strong></td>
</tr>
<tr>
<td>Mars Atmospheric Dust Opacity</td>
</tr>
<tr>
<td>Infrared/Radio Research</td>
</tr>
<tr>
<td>Infrared Astronomy TD/Cpo Optical Testing and Science Support Activities</td>
</tr>
<tr>
<td>Volatiles in the Solar System</td>
</tr>
<tr>
<td>The Development of a Mid-Infrared Spectrometer for the Infrared Telescope in Space</td>
</tr>
<tr>
<td>Two Phase Nebulae</td>
</tr>
<tr>
<td><strong>INJECTION LASERS</strong></td>
</tr>
<tr>
<td>Information and Controls Research and Technology</td>
</tr>
<tr>
<td><strong>INJECTORS</strong></td>
</tr>
<tr>
<td>Earth-to-Orbit Transportation</td>
</tr>
<tr>
<td><strong>INNER RADIATION BELT</strong></td>
</tr>
<tr>
<td>Thermospheric-Ionospheric-Mesosphere-Magnetosphere Interactions</td>
</tr>
<tr>
<td><strong>INSULATION</strong></td>
</tr>
<tr>
<td>Remote Sensing of Air-Sea Fluxes</td>
</tr>
<tr>
<td><strong>INSPECTION</strong></td>
</tr>
<tr>
<td>Aging Aircraft</td>
</tr>
<tr>
<td>Automation and Robotics</td>
</tr>
<tr>
<td><strong>INTEGRATED CIRCUITS</strong></td>
</tr>
<tr>
<td>Space Energy Conversion Research and Technology</td>
</tr>
<tr>
<td>Information and Controls Research and Technology</td>
</tr>
<tr>
<td>Information and Communications</td>
</tr>
<tr>
<td><strong>INTEGRATED MISSION CONTROL CENTER</strong></td>
</tr>
<tr>
<td>Expert Systems for Automation of Operations</td>
</tr>
<tr>
<td><strong>INTERACTIONS</strong></td>
</tr>
<tr>
<td>Forest/Climate Interactions</td>
</tr>
</tbody>
</table>
ERIS 1 Naskar Permatrost Penetration
464-21-01
Studies of Sea Surface Temperature and Topography
578-22-20
ERIS 1 Studies of Forest Ecosystems
579-4-08
MISSION PLANNING
W93-70407
MINERALS
W93-70432
MINERAL METABOLISM
W93-70298
MILLIMETER WAVES
W93-70194
Wind Measurement Assessment
460-2-841
MM and Sub-MM Radiometry
464-1-206
NDC Microwave Instrument Support
579-30327
Milimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research
464-1-301
MIND (COMPUTERS)
W93-70258
Earth and Space Sciences
509-20-00
MINERAL ANALYSIS
W93-70236
Planetary Materials: Minerals and Petrology
152-11-40
Planetary Materials: Experimental Petrology
152-12-40
Planetary Materials: Carbonaceous Meteorites and Cometary Ice Analogs
579-3-0145
Observations of the Moon, Mercury, and Primitive Asteroids
96-41-03
W93-70217
Multispectral Analysis of the Stratalographic Record, Southwest Mexico
465-45-03
MINERALS
W93-70409
Planetary Materials: Experimental Petrology
152-11-40
Carbon Mass Balance During Soil Evolution Along Climate Gradients
465-45-01
MINERALIZATION
W93-70115
Observatory Systems
582-04-00
Micro Weather Stations for Mars
579-04-06
MIRRORS
W93-70171
Astronomical Imaging Telescope
157-03-70
Optical Technology for Space Astronomy
188-41-23
High Throughput X-Ray Spectroscopy
188-46-59
AVRIS Operations
W93-70464
MISSION PLANNING
W93-70200
Hyperspectral Research and Technology
505-70-00
Propulsion Research and Technology
506-42-00
Propulsion Research and Technology
506-42-00
System Analysis
506-49-00
Systems Analysis
506-49-00
Surface Systems
583-02-00
Mars Data Analysis
155-20-00
Planetary Data System
155-20-00
Mars 94 Gravity
155-20-03
Planetary Instrument Development Program/Planetary Astronomy High Temperature Superconductor
157-05-05
Optical Stellar Interferometry
188-41-21
Astrotech 21
188-7-44
Radiation Health
199-04-11
Controlled Ecological Life Support Systems (CELSS) Project
199-61-11
Ocean Color Data System
428-82-06
Interdisciplinary ATD Studies
433-04-00
Airborne Science Management Operating Working Group Support
462-79-00
AVRIS Operations
W93-70364
Stratospheric Processes and Atmospheric Chemistry Studies
464-1-40-00
W93-70373
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Data Analysis
578-10-00
Modeling and Data Analysis, Physical Climate and Hydrological Systems, Modeling
578-40-00
Planning and Scheduling Systems Technology
W93-70534
MINING CIRCITS
W93-70112
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar
188-44-24
MOBILE COMMUNICATION SYSTEMS
W93-70209
Space Communications Research and Technology
506-12-70
MODELS
W93-70275
40 Data Assimilation for EOS
426-81-04
Forest/Climate Interactions
462-21-00
Hydrodynamic Processes Program Support for Modeling and Data Analysis
579-97-12
MODEMS
W93-70446
Space Communications Research and Technology
506-72-00
Application of Remote Sensing Imagery to Nonleptic Problems in the Baja California Peninsula
465-42-06
MODULATION
W93-70406
Proposal for a High-Energy Imaging Device (HEID) on a Balloon
879-11-48
Communications and Telemetry
310-20-70
Network Signal Processing
310-30-70
Communication Systems Research
310-30-71
MODELS
W93-70544
Space Flight Research and Technology
506-48-00
MOISTURE CONTENT
W93-70078
Modeling and Multispectral Satellite Data Analysis for Land Surface Study with Special Emphasis on Hot Arid and Semi-Arid Regions
461-3-01
Desert Mesoscale/PBL
W93-70322
Synthetic Aperture Microwave Radiometer
462-26-01
ECHIVAR Field Experiment in Desertification-Threatened Area (EFEDA)
463-32-61
Optical Scattering of Plant Canopies
462-61-00
Visitting Scientists
462-76-48
Extension and Testing of the Hydrologic Parameterization in the GISS Atmosphere GCM
578-11-02
Geographical Information System for Fusion and Analysis of High Resolution Remote Sensing and Ground Truth Data
565-65-22
MOHAVE DESERT (CA)
W93-70392
Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment
188-44-21
MOLECULAR BEAM EPITAXY
W93-70188
Band Structure Engineering on Silicon CCDs for Enhanced UV Response
189-41-24
MOLECULAR BIOLOGY
W93-70228
Space Radiation
199-04-14
Coil and Development Biology
199-40-21
MOLECULAR CLOUDS
W93-70299
Optical/UV Laboratory Astrophysics
188-41-57
MOJAVE DESERT (CA)
W93-70191
Submillimeter Astronomy
188-44-23
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar
188-44-24
Theoretical Studies of Galaxies, the Interstellar Medium, Molecular Clouds, Star Formation
188-44-53
Laboratory Astrophysics
188-44-57
Properties of interstellar PAH's
188-44-23
Center for Star Formation Studies
399-20-01
MOLECULAR GASES
W93-70260
Spectral and Physical Properties of Planetary Atmospheric Constituents
154-50-80
Submillimeter Astronomy
188-44-23
Measurement of Volcanic Gases
464-45-05
MOLECULAR INTERACTIONS
W93-70414
Chemical Kinetics and Spectroscopy of Planetary Molecules and Radicals
154-75-80
Laboratory Astrophysics
188-44-57
MOLECULAR IONS
W93-70201
Propulsion Research and Technology
506-42-00
MOLECULAR SPECTRA
W93-70070
Spectral and Physical Properties of Planetary Atmospheric Constituents
154-50-80
Laser Laboratory Spectroscopy
506-42-00
Near IR
W93-70282
Millimeter and Submillimeter Spectroscopy in Support of Upper Atmospheric Research
464-23-10
MOLECULES
W93-70383
Photoprocesses/Scintiscopies of Astrophysical Molecules and Radicals
188-41-57
Optical/UV Laboratory Astrophysics
188-41-57
Laboratory Astrophysics
188-44-57
Probitric Evolution
199-52-22
Advanced Programs Theoretical Biology
199-55-19
Origins of Solar Systems
452-23-94
Quantitative Infrared Spectroscopy of Minor Constituents of the Earth's Stratosphere
464-23-00
Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements
464-23-08
MOLBYDENUM
W93-70076
Materials and Structures Research and Technology
506-43-00
MOMENTS OF INERTIA
W93-70369
Geophysical Analysis and Modeling of LLR Data
579-36-09
MOMENTUM
W93-70461
ERS-1 SAR Investigation of Ice Kinematics and Surface Wind Fields in the Weddell Sea
665-35-10
MOMENTUM TRANSFER
W93-70502
Convective Transport in the Solar Nebula
452-22-91
Altimeter Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies: Physical Principles and Advanced Techniques
481-33-02
MONTES
W93-70325
Information and Controls Research and Technology
506-50-00
In-Space Technology Experiments
506-74-00
Foreign Visitor Support
429-97-04
DSN Data Processing and Productivity
310-40-73
MONOTECTIC ALLOYS
W93-70551
Metals and Alloys
674-25-08
MONTE CARLO METHOD
W93-70514
Gamma-Ray Astronomy and Technology Development
188-46-57
Retracking of Topex Waveform Data
461-34-01
# NOISE MEASUREMENT

<table>
<thead>
<tr>
<th>Range</th>
<th>Code</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>537-02-00</td>
<td>W93-7005</td>
<td>W93-7003</td>
</tr>
<tr>
<td>Short-Period Tropospheric Noise in Continuous GPS Measurements</td>
<td>465-27-02</td>
<td>W93-7042</td>
</tr>
</tbody>
</table>

# NOISE POLLUTION

<table>
<thead>
<tr>
<th>System</th>
<th>Code</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Turboprop Systems</td>
<td>535-03-00</td>
<td>W93-7045</td>
</tr>
<tr>
<td>Atmospheric Effects</td>
<td>537-01-00</td>
<td>W93-7049</td>
</tr>
<tr>
<td>Community Noise and Sonic Boom</td>
<td>537-02-00</td>
<td>W93-7055</td>
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<td>Community Noise and Sonic Boom</td>
<td>537-03-00</td>
<td>W93-7057</td>
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<tr>
<td>Community Noise and Sonic Boom</td>
<td>537-04-00</td>
<td>W93-7059</td>
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# NOISE PREDICTION

<table>
<thead>
<tr>
<th>System</th>
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<tbody>
<tr>
<td>Advanced Rotorcraft Technology</td>
<td>532-06-00</td>
<td>W93-7039</td>
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<td>Advanced Turboprop Systems</td>
<td>535-03-00</td>
<td>W93-7044</td>
</tr>
<tr>
<td>Emissions and Source Noise</td>
<td>537-02-00</td>
<td>W93-7053</td>
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<td>Emissions and Source Noise</td>
<td>537-02-00</td>
<td>W93-7055</td>
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<tr>
<td>Emissions and Source Noise</td>
<td>537-02-00</td>
<td>W93-7057</td>
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# NOISE REDUCTION

<table>
<thead>
<tr>
<th>System</th>
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<tbody>
<tr>
<td>Advanced Rotorcraft Technology</td>
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<td>W93-7039</td>
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<td>Advanced Turboprop Systems</td>
<td>535-03-00</td>
<td>W93-7044</td>
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# NOISE SPECTRA

<table>
<thead>
<tr>
<th>System</th>
<th>Code</th>
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<tbody>
<tr>
<td>Short-Period Tropospheric Noise in Continuous GPS Measurements</td>
<td>465-27-02</td>
<td>W93-7042</td>
</tr>
</tbody>
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# OBSERVATIONS

<table>
<thead>
<tr>
<th>System</th>
<th>Code</th>
<th>Code</th>
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</thead>
<tbody>
<tr>
<td>Infrared and Radio Astronomical Technical Development: Ground-Based Astronomical Instrument</td>
<td>188-44-23</td>
<td>W93-70189</td>
</tr>
<tr>
<td>Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar</td>
<td>188-44-24</td>
<td>W93-70197</td>
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<tr>
<td>Gamma Ray Astronomy</td>
<td>188-46-57</td>
<td>W93-70207</td>
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<tr>
<td>Astrophysics</td>
<td>188-78-44</td>
<td>W93-70215</td>
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<tr>
<td>Infrared Laboratory Spectroscopy in Support of Stratospheric Measurements</td>
<td>464-23-06</td>
<td>W93-70381</td>
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<tr>
<td>Active Deformation in the Mojave Desert and Walker Lane: A Global Positioning System Experiment</td>
<td>465-13-06</td>
<td>W93-70396</td>
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<td>GPS/VLBI: Vertical Measurement</td>
<td>465-14-09</td>
<td>W93-70396</td>
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<thead>
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<td>Advanced Programs Theoretical Biology</td>
<td>199-55-19</td>
<td>W93-70252</td>
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<tr>
<td>Modeling of the Main Magnetic Field</td>
<td>539-31-02</td>
<td>W93-70457</td>
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</table>

# OCEAN BOTTOM

<table>
<thead>
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<td>Advanced Programs Theoretical Biology</td>
<td>199-55-19</td>
<td>W93-70252</td>
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<tr>
<td>Modeling of the Main Magnetic Field</td>
<td>539-31-02</td>
<td>W93-70457</td>
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</tbody>
</table>

# OCEAN COLOR SCANNER

<table>
<thead>
<tr>
<th>System</th>
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</thead>
<tbody>
<tr>
<td>Ocean Color Data System</td>
<td>426-82-06</td>
<td>W93-70727</td>
</tr>
<tr>
<td>SeaWiFS Calibration/Validation</td>
<td>463-11-01</td>
<td>W93-70355</td>
</tr>
</tbody>
</table>
### RADAR ANTIMNAS

- **Airborne Interferometric Topography**
  - W93-70350

### RADAR ANTIMONY

- **Advanced Transmitter System Development**
  - W93-70308

### RADAR CORNER REFLECTORS

- **ERS SAR** 1-52 and 5-20, 665-35-10
  - W93-70302

### RADAR CROSS SECTIONS

- **Altimeter Measurement of Wind Speed and Sea Level Height** 486-61-01, 486-62-01
  - W93-70304

### RADAR DATA

- **Global Assessment of Active Volcanism** 429-81-95
  - W93-70286
- **Measuring Soil Moisture With Imaging Radar** 461-13-00
  - W93-70300
- **Microwave Process Studies of Sea Ice Properties** 461-62-10
  - W93-70333
- **Polarimetric Data Analysis**
  - W93-70429
- **Automated Geophysical Processor Development for the Alaska SAR Facility** 428-82-11
  - W93-70273
- **Airborne Precipitation Radar** 451-61-16, 451-62-04
  - W93-70336
- **Ice Sheet Geophysical Investigations Using Imaging Radar** 461-66-16, 461-68-11
  - W93-70715
- **Field Experiment in Desertification-Threatened Area (EPEDA)** 482-32-61
  - W93-70422
- **Airborne Interferometric Topography** 482-74-01
  - W93-70600
- **ERS-1 SAR Permanifold Penetration** 485-40-01
  - W93-70407
- **Airborne Synthetic Aperture Radar (AIRSAR) Operations** 485-68-01
  - W93-70420
- **Mapping of the Greenland Ice Sheet: A Contribution to the Monitoring of Global Climate** 561-25-01
  - W93-70395
- **Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR** 578-35-02
  - W93-70340
- **Geographical Information System for Fusion and Analysis of Ice and Snow Remote-Sensing Data** 665-65-22
  - W93-70493
- **Advanced Search and Rescue Techniques** 669-30-10
  - W93-70504

### RADAR MAPS

- **Airborne Interferometric Topography**
  - W93-70350
- **Airborne Interferometric Topography** 486-67-04
  - W93-70419

### RADAR MEASUREMENT

- **CO2 Laser Backscatter Experiment** 460-21-00
  - W93-70309
- **Airborne Doppler Lidar** 460-21-52
  - W93-70311
- **Wind Measurement Assessment** 460-23-41
  - W93-70313
- **Scatterometer Research**
  - W93-70323
- **Radar Scattering Inversion: Forested Areas**
  - W93-70284
- **Satellite Observations of Volcanic Aerosols** 465-44-00
  - W93-70140

### RADAR NETWORKS

- **Airborne Interferometric Topography**
  - W93-70350
- **Airborne Interferometric Topography**
  - W93-70401
- **Remote Sensing** 562-01-00
  - W93-70113

### RADAR RECEIVERS

- **Science Sensing (Remote)**
  - W93-70300
- **Measuring Soil Moisture With Imaging Radar** 461-13-00
  - W93-70320
- **Radar Scattering Inversion: Forested Areas**
  - W93-70328

### RADAR SIGNATURES

- **ERS-1 Studies of Forest Ecosystems** 579-41-06
  - W93-70466

### RADAR TARGETS

- **Lidar Target Calibration Facility** 460-22-52
  - W93-70312
- **Advanced Search and Rescue Techniques** 669-30-10
  - W93-70504

### RADAR TRACKING

- **Relativity, Cosmology, and Gravitational Radiation** 429-81-95
  - W93-70185
- **Automated Geophysical Processor Development for the Alaska SAR Facility**
  - W93-70273
- **Polar Exchange at the Sea Surface: JPL Component**
  - W93-70282
- **Global Assessment of Active Volcanism**
  - W93-70286
- **Active/Passive Sea Ice Analysis** 578-32-24
  - W93-70437
- **Monitoring the Seasonal Cycle of Sea Ice in the Arctic Basin for Climate Change with ERS-1 SAR** 578-35-04
  - W93-70440

### RADIANCE

- **Thermal Infrared Science Support** 462-75-74
  - W93-70352
- **AVIRIS Operations** 465-44-14
  - W93-70417
- **Outgoing Spectral Radiance: A Climate Diagnostic** 578-12-59
  - W93-70429
- **Estimation of Greenland Sea Ice and Freshwater Fluxes from ERS-1 and SSM/I Data** 665-35-09
  - W93-70501

### RADIANT FLUX DENSITY

- **ERS Science** 429-81-38
  - W93-70281
- **Radiative Effects in Clouds First International Satellite Cloud Climatology Regional Experiment**
  - W93-70315

### RADAR DETECTORS

- **Science Sensing (Remote)**
  - W93-70109
- **Science Sensing (Remote)** 582-03-00
  - W93-70110
- **Gamma Ray Astronomy and Technology Development**
  - W93-70206
- **High Energetic X Ray Spectroscopy**
  - W93-70210
- **Integral Mission Definition Study**
  - W93-70211
- **Gravity Wave Mission Definition Study**
  - W93-70212

### RADIATION DISTRIBUTION

- **Space Radiation Effects and Protection (Environmental Health)**
  - W93-70225
- **Radiation Health**
  - W93-70226
- **Space Radiation**
  - W93-70228

### RADIATION SHIELDING

- **Experimental Cloud Analysis Techniques** 462-33-03
  - W93-70341
- **Heterogeneous Scene Models**
  - W93-70347
- **Measurement of Volcanic Gases**
  - W93-70404
- **Climate Modeling with Emphasis on Aerosols and Clouds**
  - W93-70414
- **Experimental Cloud Analysis Techniques** 578-10-01
  - W93-70422
- **Outgoing Spectral Radiance: A Climate Diagnostic**
  - W93-70424
- **Two-Dimensional Stratospheric Chemical Model - Radiation**
  - W93-70429
- **Modeling and Multispectral Satellite Data Analysis** for Land Surface Study with Special Emphasis on Hot And Semi-And Regions
  - W93-70321
- **VARIATIONS OF SOIL MOISTURE AND OTHER SURFACE PARAMETERS DURING HAPEX-Sahel Experiment**
  - W93-70431

### RADICALS

- **Stratospheric Processes and Atmospheric Chemistry Studies**
  - W93-70373
- **Large Scale Air-Sea Interactions**
  - W93-70433
- **Radar Attenuation Ice Data System**
  - W93-70448
- **Infrared and Radiative Atmospheric Techniques Development: Ground-Based Astronomical Instrument**
  - W93-70195
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPACECRAFT PERFORMANCE</strong></td>
</tr>
<tr>
<td>Materials and Structures Research and Technology</td>
</tr>
<tr>
<td>W93-70043</td>
</tr>
</tbody>
</table>

| **SPACECRAFT POWER SUPPLIES** |
| Space Energy Conversion Research and Technology |
| W93-70040 |
| Space Energy Conversion Research and Technology |
| W93-70041 |
| Space Energy Conversion Research and Technology |
| W93-70042 |
| Materials and Structures Research and Technology |
| W93-70045 |
| Space Flight Research and Technology |
| W93-70048 |
| In-Space Technology Experiments |
| W93-70049 |
| Surface Systems |
| W93-70050 |
| Earth-Orbiting Platforms |
| W93-70051 |
| Automation and Robotics |
| W93-70052 |
| **SPACECRAFT PROPULSION** |
| Materials and Structures Research and Technology |
| W93-70053 |
| Propulsion Research and Technology |
| W93-70054 |
| Propulsion Research and Technology |
| W93-70055 |
| Materials and Structures Research and Technology |
| W93-70056 |
| In-Space Technology Experiments |
| W93-70057 |
| Materials and Structures Research and Technology |
| W93-70058 |
| **SPACECRAFT TEMPERATURE** |
| In-Space Technology Experiments |
| W93-70059 |
| **SPACECRAFT TRACKING** |
| GPS-Based DSN Calibration System |
| W93-70060 |
| **SPACECRAFT SOFTWARE** |
| In-Space Experiments |
| W93-70061 |
| Clinical Medicine Technology Watch |
| W93-70062 |
| **SPACECRAFT TRACKING** |
| ERS-1 Studies |
| W93-70063 |
| Satellite Observations of Volcanic Aerosols |
| W93-70064 |
| Airborne IR Spectrometry |
| W93-70065 |
| Parameters During HAPEX-Sahel Experiment |
| W93-70066 |
| ECHIVAL Field Experiment |
| W93-70067 |
| Measuring Soil Moisture With Radar |
| W93-70068 |
| **SPACECRAFT STRUCTURES** |
| Materials and Structures Research and Technology |
| W93-70069 |
| Materials and Structures Research and Technology |
| W93-70070 |
| Materials and Structures Research and Technology |
| W93-70071 |
| In-Space Technology Experiments |
| W93-70072 |
| Materials and Structures Research and Technology |
| W93-70073 |
| **SPACECRAFT TEMPERATURE** |
| In-Space Technology Experiments |
| W93-70074 |
| **SPACECRAFT TRACKING** |
| GPS-Based DSN Calibration System |
| W93-70075 |
| **SPACECRAFT TRACKING** |
| In-Space Experiments |
| W93-70076 |
| Clinical Medicine Technology Watch |
| W93-70077 |
| **SPACECRAFT TRACKING** |
| ERS-1 Studies |
| W93-70078 |
| Satellite Observations of Volcanic Aerosols |
| W93-70079 |
| Airborne IR Spectrometry |
| W93-70080 |
| Parameters During HAPEX-Sahel Experiment |
| W93-70081 |
| ECHIVAL Field Experiment |
| W93-70082 |
| Measuring Soil Moisture With Radar |
| W93-70083 |
| **SPACECRAFT TRACKING** |
| ERS-1 Studies |
| W93-70084 |
| Satellite Observations of Volcanic Aerosols |
| W93-70085 |
| Airborne IR Spectrometry |
| W93-70086 |
| Parameters During HAPEX-Sahel Experiment |
| W93-70087 |
| ECHIVAL Field Experiment |
| W93-70088 |
| Measuring Soil Moisture With Radar |
| W93-70089 |
WINTER

ERS-1 Radar Permafrost Penetration 465-41-01 W93-70407
Stratospheric Chemical Model: Dynamics 579-23-10 W93-70452
ERS-1 SAR Investigation of Ice Kinematics and Surface Winds in the Weddell Sea 665-35-10 W93-70502

WORD PROCESSING

Windows on Global Change 665-82-03 W93-70503

WORK CAPACITY


WORKLOADS (PSYCHOPHYSIOLOGY)

Behavior, Performance and Human Factors 199-06-12 W93-70231

WORKSTATIONS

Systems Analysis 505-69-00 W93-70016
Numerical Aerodynamic Simulation (NAS) 536-01-00 W93-70047
NAS Operations 536-02-00 W93-70048
A 4D Data Assimilation for EOS Computer Support 428-81-04 W93-70262
Global Assessment of Active Volcanism 428-81-94 W93-70269
LTP Computer Support 579-41-04 W93-70465
A Distributed Analyses and Visualization System for Model and Observational Data 564-65-27 W93-70497
Windows on Global Change 665-62-03 W93-70503
Planning and Scheduling Systems Technology 310-20-36 W93-70534
Mission Operations Technology 310-40-45 W93-70546

X-RAY ASTRONOMY

Gamma Ray Astronomy 188-46-57 W93-70207
High Energy Astrophysics International Programs 440-62-59 W93-70299

X-RAYS

Information and Controls Research and Technology 506-59-00 W93-70090
Planetary Materials: Chemistry 152-13-40 W93-70144
Optical Technology for Space Astronomy 188-41-23 W93-70186

X-RAY DETECTORS

High Throughput X-Ray Spectroscopy 188-46-59 W93-70209

X-RAY FLUORESCENCE

Planetary Materials: Chemistry 152-13-40 W93-70144

X-RAY IMAGERY

X-Ray Astronomy CCD 188-46-59 W93-70209

X-RAY SOURCES

High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies 188-46-01 W93-70205
X-Ray Astronomy CCD 188-46-59 W93-70209
High Throughput X-Ray Spectroscopy 188-46-59 W93-70210

X-RAY SPECTRA

Optical/UV Laboratory Astrophysics 188-41-57 W93-70191

X-RAY SPECTROSCOPY

Planetary Instrument Definition and Development 157-03-50 W93-70169
High Throughput X-Ray Spectroscopy 188-46-59 W93-70210

X-RAY TELESCOPES

High Energy Astrophysics: Data Analysis, Interpretation and Theoretical Studies 188-46-01 W93-70205

Y

YAG LASERS

Planetary Orbital/Flyby Laser Altimeter 157-03-80 W93-70172
NDSC Differential Absorption Lidar 464-13-15 W93-70371

Z

ZONE MELTING

Electronic Materials 674-21-08 W93-70506
Metals and Alloys 674-25-05 W93-70513
**TECHNICAL MONITOR INDEX**

**FISCAL YEAR 1993**

### B

<table>
<thead>
<tr>
<th>TITLE</th>
<th>RTOP NUMBER</th>
<th>ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAGWELL, J. W.</td>
<td>506-72-00</td>
<td>W93-70096</td>
</tr>
<tr>
<td>BAILEY, F. R.</td>
<td>505-59-00</td>
<td>W93-70001</td>
</tr>
<tr>
<td>BALLARD, R. W.</td>
<td>159-40-72</td>
<td>W93-70244</td>
</tr>
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<td>BALOGA, S. M.</td>
<td>506-43-00</td>
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### C

<table>
<thead>
<tr>
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<th>RTOP NUMBER</th>
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<tbody>
<tr>
<td>CAMPBELL, J. K.</td>
<td>510-02-00</td>
<td>W93-70211</td>
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<tr>
<td>CARLE, G. C.</td>
<td>510-02-00</td>
<td>W93-70034</td>
</tr>
<tr>
<td>CASEY, F. D.</td>
<td>510-02-00</td>
<td>W93-70035</td>
</tr>
<tr>
<td>CASSEN, P.</td>
<td>510-02-00</td>
<td>W93-70036</td>
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<td>CASTLES, S.</td>
<td>510-02-00</td>
<td>W93-70037</td>
</tr>
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<td>CHACKERIAN, C. J.</td>
<td>510-02-00</td>
<td>W93-70038</td>
</tr>
<tr>
<td>CHADWICK, O. A.</td>
<td>510-02-00</td>
<td>W93-70039</td>
</tr>
<tr>
<td>CHAFFEE, N. H.</td>
<td>510-02-00</td>
<td>W93-70040</td>
</tr>
<tr>
<td>CHAIWITE, M. T.</td>
<td>510-02-00</td>
<td>W93-70041</td>
</tr>
<tr>
<td>CHIEN, R. H.</td>
<td>510-02-00</td>
<td>W93-70042</td>
</tr>
<tr>
<td>CHIUEH, G. L.</td>
<td>510-02-00</td>
<td>W93-70043</td>
</tr>
<tr>
<td>CHING, W. S.</td>
<td>510-02-00</td>
<td>W93-70044</td>
</tr>
<tr>
<td>CHINCHILLA, I.</td>
<td>510-02-00</td>
<td>W93-70045</td>
</tr>
<tr>
<td>CHIRURU, I. M.</td>
<td>510-02-00</td>
<td>W93-70046</td>
</tr>
<tr>
<td>CHUANG, C. H.</td>
<td>510-02-00</td>
<td>W93-70047</td>
</tr>
<tr>
<td>CHUAN, S. W.</td>
<td>510-02-00</td>
<td>W93-70048</td>
</tr>
<tr>
<td>CHUANG, W. C.</td>
<td>510-02-00</td>
<td>W93-70049</td>
</tr>
<tr>
<td>CHUNG, C. K.</td>
<td>510-02-00</td>
<td>W93-70050</td>
</tr>
<tr>
<td>CHUNG, H. K.</td>
<td>510-02-00</td>
<td>W93-70051</td>
</tr>
<tr>
<td>CHUNG, S. J.</td>
<td>510-02-00</td>
<td>W93-70052</td>
</tr>
<tr>
<td>CHUNG, W. C.</td>
<td>510-02-00</td>
<td>W93-70053</td>
</tr>
</tbody>
</table>

### RTOP SUMMARY

**TECHNICAL MONITOR INDEX**

<table>
<thead>
<tr>
<th>TITIE</th>
<th>RTOP NUMBER</th>
<th>ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARNOLD, J. D.</td>
<td>506-43-00</td>
<td>W93-70062</td>
</tr>
<tr>
<td>ARNOLDS, D. F.</td>
<td>506-43-00</td>
<td>W93-70071</td>
</tr>
</tbody>
</table>

**ARGUS, D. F.**

Aerothermodynamics Research and Technology

**ALLEN, ALLARIO, ALLAMANDOLA, ALBER, ABBRAS, M. J.**

Aerothermodynamics Research and Technology

**ABSHIRE, JAMES B.**

Aerothermodynamics Research and Technology

**ABRAMS, M. J.**

Aerothermodynamics Research and Technology

**ABEL, PETER**

Aerothermodynamics Research and Technology

**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**

### In-Flight Experiment Accession Numbers

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>506-72-00</td>
<td>W93-70096</td>
</tr>
<tr>
<td>505-59-00</td>
<td>W93-70001</td>
</tr>
<tr>
<td>159-40-72</td>
<td>W93-70244</td>
</tr>
<tr>
<td>506-43-00</td>
<td>W93-70071</td>
</tr>
</tbody>
</table>

**AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY**

### In-Flight Experiment Accession Numbers

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>506-72-00</td>
<td>W93-70096</td>
</tr>
<tr>
<td>505-59-00</td>
<td>W93-70001</td>
</tr>
<tr>
<td>159-40-72</td>
<td>W93-70244</td>
</tr>
<tr>
<td>506-43-00</td>
<td>W93-70071</td>
</tr>
</tbody>
</table>
MOACANIN, J.
Materials and Structures Research and Technology
506-43-00 W93-70075

MOE, KAREN L.
Planning and Scheduling Systems Technology
310-20-36 W93-70534

MORRISSEY, L. A.
ERS-1 SAR Investigations of Methane Emissions from High Latitude Ecosystems
665-35-00 W93-70499

MOSES, J. L.
Earth-to-Orbit Transportation
584-03-00 W93-70121

MUMMA, MICHAEL J.

NEAL, HOWARD L.

NUTH, C. J.

PERIODICAL INDEX

PIERT, E. C.

PIETRASZYK, P.

PLESSCHER, R. F.

POLLACK, J. B.

POLLARA, FABRIZIO

POTTER, A. E.

PREHEIM, L. E.

PRESTON, R. A.

PRITCHARD, JAMES A.

PUESCHEL, R. F.

PYLE, JOHN S.

RANDOLPH, J. E.

RAPER, O. F.

RAYMAN, M. D.

REALMUTO, V. J.

RECK, GREGORY, M.

REITER, D. C.

RING, DAVID

ROBINSON, MICHAEL B.

RODRIGUEZ, E.

ROBINSON, MICHAEL E.

RIND, DAVID

RIPPEL, H.

RIVIERE, D. M.

ROBERTSON, G. M.

ROCYK, R.

RODSAY, WILLIAM B.

RODRIGUEZ, R.

ROSMAN, R.

ROSEN, J.

ROSEN, M. D.

ROTH, R.

ROUSSY, J.

RUDOLPH, T.

RUFF, THOMAS J.

RUMBLE, D.

RUSSELL, P. B.

RUSSEL, R. M.

SAATCHE, S. S.

SAMS, C.

SANDER, S. P.

SARKEYA, N.

SCHULZ, J. A.

SCHINDLER, MARK R.

SCHIFF, N.

SCHANZEL, P.

SHAW, NANCY J.

SHEPPARD, S. B.

SHI, Y.

SHIH, ALBERT

SHOCK, W. B.

SHAW, J. A.

SHAW, J.

SHAW, R. L.

SHAW, W. M.

SHAW, W.

SHAW, W. T.

SHEPPARD, S. B.

SHEPPARD, S. B.

SHEPPARD, S. B.

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SHEPPARD, S. B.

SHEPPARD, S. B.

SHEPPARD, S. B.

SHEPPARD, S. B.

SHEPPARD, S. B.
YODER, C. F.
Space Science
151-01-70 W93-70139
Earth Rotation and Mantle Structure
576-36-03 W93-70460

YOUNG, R. E.
Dynamics of Planetary Atmospheres
154-20-80 W93-70153
Volcanic Cloud Dispersion, Chemistry and Microphysics
465-44-06 W93-70415

ZEBKER, H. A.
Global Assessment of Active Volcanism
429-81-95 W93-70286
Radar Scattering Inversion: Forested Areas
462-62-04 W93-70348
Airborne Interferometric Topography
462-74-01 W93-70350
ASF SAR Interferometry
665-25-01 W93-70500

ZIEMANIAKI, J. A.
Propulsion and Power Research and Technology
505-62-00 W93-70004
Flight Systems Research and Technology
505-68-00 W93-70014
High Performance Flight Research
533-02-00 W93-70042
Advanced Turboprop Systems
533-03-00 W93-70044
GA/Commuter Engine Technology
535-25-02 W93-70046

ZLOTNICKI, V.
Studies of Sea Surface Temperature and Topography
578-22-25 W93-70435
JPL Oceanography Group Computer System
578-22-27 W93-70434

ZUREK, R. W.
Project to Interface Modeling: EOSDIS Activities
428-81-72 W93-70287
Project to Interface Modeling
429-81-72 W93-70283
Stratospheric Chemical Model: Dynamics
579-23-10 W93-70452

ZWALLY, H. J.
Radar Altimeter Ice Data System
578-97-20 W93-70448
The plant 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.

J

JPL
Aerodynamics Research and Technology
505-59-00 W93-70003
Earth and Space Sciences
509-20-00 W93-70005
Space Energy Conversion Research and Technology
506-41-00 W93-70067
Propulsion Research and Technology
506-42-00 W93-70070
Materials and Structures Research and Technology
506-43-00 W93-70075
Systems Analysis
506-49-00 W93-70085
Information and Controls Research and Technology
506-59-00 W93-70091
Human Support Research and Technology
506-71-00 W93-70094
Space Communications Research and Technology
506-72-00 W93-70099
Science Sensing (Remote)
506-75-00 W93-70110
Surface Systems
583-02-00 W93-70117
Earth-To-Orbit Transportation
584-03-00 W93-70119
Automation and Robotics
586-02-00 W93-70130
Information and Communications
586-03-00 W93-70137
Planetary
510-01-70 W93-70139
Study of Potential Mars Observer - Mars 94, 96 Flight Path Cooperatives
152-88-10 W93-70161
Mars Atmosphere Dust Opacity
155-04-00 W93-70163
U.S. Participating Scientist MARS 94/96 - Mars Global Geodesy
155-20-02 W93-70166
Mars 94 Gravity
155-20-03 W93-70167
Mars 94 Winds
155-20-04 W93-70168
Astrometric Imaging Telescope
157-03-70 W93-70171
Micro Weather Stations for Mars
157-04-00 W93-70174
Cosmic and Heliophysics
170-10-10 W93-70177

Solar Physics Studies W93-70181
Deep Optical UV Imaging of Quasars Below the Lyman Limit
186-41-21 W93-70183
Optical Stellar Interferometry
186-41-21 W93-70184
Relativity, Cosmology, and Gravitational Radiation
186-41-22 W93-70185
Band Structure Engineering on Silicon CCDs for Enhanced UV Response
186-41-24 W93-70186
Optical UV Laboratory Astrophysics
186-41-57 W93-70191
Infrared/Radio Research
186-44-21 W93-70193
Submillimeter Astronomy
188-44-23 W93-70194
Development of 1036 GHz Receiver for Astronomy and Near IR Imaging at Palomar
188-44-24 W93-70197
Simulations of Compact Radio Sources
188-44-53 W93-70198
Laboratory Astrophysics
188-44-57 W93-70201
Gamma-Ray Astronomy and Technology Development
188-46-57 W93-70206
X-Ray Astronomy CCD
188-46-59 W93-70209
Gravity Wave Mission Definition Study
188-78-01 W93-70212
Optical Interferometry in Space
188-78-41 W93-70213
Astromech 21
188-78-44 W93-70215
Space Radiation
190-04-14 W93-70228
Musculoskeletal
199-26-14 W93-70238
Exobiology Intact Capture Technology Development
199-52-54 W93-70250
HIPPARCOS VLBI
399-18-00 W93-70256
Energetics of Interstellar Clouds
399-20-00 W93-70257
IPAC Astrophysics Data System (ADS) Support
399-20-00 W93-70258
NASA/IPAC Extragalactic Database
399-20-20 W93-70259
Role of Air-Sea Exchanges and Ocean Circulation (Computing)
428-81-10 W93-70263
Project to Interface Modeling: EOSDIS Activities
428-81-72 W93-70267
Global Assessment of Active Volcanism
428-81-95 W93-70269
Global Assessment of Active Volcanism
428-81-96 W93-70270
Automated Geophysical Processor Development for the Alaska SAR Facility
428-82-11 W93-70273
Role of Air-Sea Exchanges and Ocean Circulation (Science)
429-81-10 W93-70277
Polar Exchange at the Sea Surface: JPL Component
429-81-64 W93-70282
Project to Interface Modeling
429-81-72 W93-70283
Global Assessment of Active Volcanism
429-81-85 W93-70285
Global Assessment of Active Volcanism
429-81-86 W93-70286
Global Assessment of Active Volcanism
429-81-95 W93-70287
Global Assessment of Active Volcanism
429-81-96 W93-70288
Magnetospheric Coupling
432-36-00 W93-70293
Interdisciplinary ATD Studies
432-04-00 W93-70295
Solar Probe ATD
432-06-00 W93-70296
Space Physics Program Support/Detials
432-90-00 W93-70297
Origin of Solar Systems
452-23-94 W93-70305
IR Remote Sensing of SST
460-21-28 W93-70310
Airborne Doppler Lidar
460-21-52 W93-70311
Lidar Target Calibration Facility
460-22-52 W93-70312
Atmospheric Backscatter Experiment
460-22-53 W93-70313
Wind Measurements Assessment
460-28-41 W93-70314
Measuring Soil Moisture With Imaging Radar
461-13-00 W93-70320
Scatterometer Research
461-31-09 W93-70323
Scatterometer Studies
461-31-13 W93-70324
Global Measurements of Wind Speed and Sea Level Height With Applications to Air-Sea Interaction Studies
461-33-02 W93-70325
Retracking of Topex Waveform Data
461-34-01 W93-70326
Monitoring Global Sea Level with Altimeter Transponders
461-38-02 W93-70328
GEWEX Program Support
461-50-03 W93-70321
Airborne Precipitation Radar
461-51-16 W93-70322
Microwave Process Studies of Sea Ice Properties
461-62-10 W93-70333
Polarimetric Data Analysis
461-64-11 W93-70334
Oceanic Remote Sensing Library
461-66-16 W93-70335
Ice Sheet Geophysical Investigations Using Imaging Radar
461-66-18 W93-70336
ECHIVALE Field Experiment in Desertification/Threatened Area (EFEDA)
462-32-61 W93-70342
Satellite Radar for Forest Structure
462-41-61 W93-70343
Heterogeneous Scene Models
462-61-03 W93-70347
Radar Scattering Inversion: Forested Areas
462-62-04 W93-70348
Soil Moisture from SAR
462-62-05 W93-70349
Airborne Interferometric Topography
462-74-01 W93-70350
Airborne Synthetic Aperture Radar (AirSAR) Operations
462-75-62 W93-70351
Thermal Infrared Science Support
462-75-74 W93-70352
Visting Scientists
462-76-49 W93-70353
Phytoplankton Dynamics of North Pacific Ocean
462-11-09 W93-70356
Bio-Optical Interpretation of Ocean Color Imagery
462-11-62 W93-70357
AVIRIS Operations
463-75-63 W93-70364
Ozone Measurements
464-21-05 W93-70365
Laser Dose Sensor
464-11-07 W93-70366
IR Solar Absorption Spectra
464-12-05 W93-70368
MM and Sub-MM Radiometry
464-13-06 W93-70369
Far Infrared Balloon Radiometer for OH
464-18-15 W93-70370
NDSC Differential Absorption Lidar
464-18-15 W93-70371
NDSC Microwave Instrument Support
464-13-22 W93-70372
Microwave Temperature Profiler
464-14-20 W93-70374
Multi-Sensor Ballon Measurements
464-16-01 W93-70375
<table>
<thead>
<tr>
<th>RESPONSIBLE NASA ORGANIZATION INDEX</th>
<th>NASA, Washington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth-to-Orbit Transportation 584-03-00</td>
<td>W93-70120</td>
</tr>
<tr>
<td>Earth-Orbiting Platforms 585-03-00</td>
<td>W93-70125</td>
</tr>
<tr>
<td>Automation and Robotics 586-02-00</td>
<td>W93-70129</td>
</tr>
<tr>
<td>Information and Communications 586-03-00</td>
<td>W93-70135</td>
</tr>
<tr>
<td>Space Radiation Effects and Protection (Environmental Health) 199-04-00</td>
<td>W93-70225</td>
</tr>
<tr>
<td>EOS Science 429-81-38</td>
<td>W93-70281</td>
</tr>
<tr>
<td>Biophen/c/Atmospheric Interactions 463-67-00</td>
<td>W93-70362</td>
</tr>
<tr>
<td>Satellite Observations of Volcanic Aerosols 465-44-00</td>
<td>W93-70410</td>
</tr>
<tr>
<td>Fluid Physics 674-24-00</td>
<td>W93-70510</td>
</tr>
<tr>
<td>NASA, Lewis Research Center</td>
<td></td>
</tr>
<tr>
<td>Propulsion and Power Research and Technology 505-62-00</td>
<td>W93-70004</td>
</tr>
<tr>
<td>Materials and Structures Research and Technology 505-63-00</td>
<td>W93-70008</td>
</tr>
<tr>
<td>Flight Systems Research and Technology 505-68-00</td>
<td>W93-70014</td>
</tr>
<tr>
<td>Systems Analysis 505-69-00</td>
<td>W93-70016</td>
</tr>
<tr>
<td>Hypersonic Research and Technology 505-70-00</td>
<td>W93-70022</td>
</tr>
<tr>
<td>Interdisciplinary Technology 505-90-00</td>
<td>W93-70026</td>
</tr>
<tr>
<td>Computational Aerosciences 509-10-00</td>
<td>W93-70030</td>
</tr>
<tr>
<td>Advanced High Temperature Engine Materials 510-01-00</td>
<td>W93-70036</td>
</tr>
<tr>
<td>Advanced Composite Materials Technology 510-02-00</td>
<td>W93-70037</td>
</tr>
<tr>
<td>High-Performance Flight Research 533-02-00</td>
<td>W93-70042</td>
</tr>
<tr>
<td>Advanced Turboprop Systems 535-03-00</td>
<td>W93-70044</td>
</tr>
<tr>
<td>GA/Commuter Engine Technology 535-05-00</td>
<td>W93-70046</td>
</tr>
<tr>
<td>Atmospheric Effects 537-01-00</td>
<td>W93-70051</td>
</tr>
<tr>
<td>Emissions and Source Noise 537-02-00</td>
<td>W93-70054</td>
</tr>
<tr>
<td>Enabling Propulsion Materials 537-04-00</td>
<td>W93-70058</td>
</tr>
<tr>
<td>Fly-By-Light/Power-By-Wire Technology 538-01-00</td>
<td>W93-70059</td>
</tr>
<tr>
<td>Space Energy Conversion Research and Technology 506-41-00</td>
<td>W93-70064</td>
</tr>
<tr>
<td>Propulsion Research and Technology 506-42-00</td>
<td>W93-70066</td>
</tr>
<tr>
<td>Materials and Structures Research and Technology 506-43-00</td>
<td>W93-70073</td>
</tr>
<tr>
<td>Space Flight Research and Technology 506-48-00</td>
<td>W93-70078</td>
</tr>
<tr>
<td>System Analysis 506-49-00</td>
<td>W93-70083</td>
</tr>
<tr>
<td>Space Communications Research and Technology 506-72-00</td>
<td>W93-70096</td>
</tr>
<tr>
<td>In-Space Technology Experiments 506-74-00</td>
<td>W93-70103</td>
</tr>
<tr>
<td>Surface Systems 583-02-00</td>
<td>W93-70116</td>
</tr>
<tr>
<td>Earth-to-Orbit Transportation 584-03-00</td>
<td>W93-70118</td>
</tr>
<tr>
<td>Space Transportation 584-04-00</td>
<td>W93-70122</td>
</tr>
<tr>
<td>Earth-Orbiting Platforms 585-03-00</td>
<td>W93-70124</td>
</tr>
<tr>
<td>Automation and Robotics 586-02-00</td>
<td>W93-70128</td>
</tr>
<tr>
<td>Electronic Materials 674-21-08</td>
<td>W93-70505</td>
</tr>
<tr>
<td>Combustion Science 674-22-05</td>
<td>W93-70507</td>
</tr>
<tr>
<td>Fluid Physics 674-24-05</td>
<td>W93-70511</td>
</tr>
<tr>
<td>Metals and Alloys 674-25-05</td>
<td>W93-70513</td>
</tr>
<tr>
<td>Glasses and Ceramics 674-26-05</td>
<td>W93-70515</td>
</tr>
<tr>
<td>Microgravity Materials Science Laboratory (MMMSL) 674-27-05</td>
<td>W93-70517</td>
</tr>
<tr>
<td>Ground Experiment Operations 674-28-05</td>
<td>W93-70518</td>
</tr>
<tr>
<td>NASA, Marshall Space Flight Center</td>
<td></td>
</tr>
<tr>
<td>Materials and Structures Research and Technology 506-43-00</td>
<td>W93-70076</td>
</tr>
<tr>
<td>In-Space Technology Experiments 506-74-00</td>
<td>W93-70106</td>
</tr>
<tr>
<td>Science Sensing (Remote) 582-03-00</td>
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