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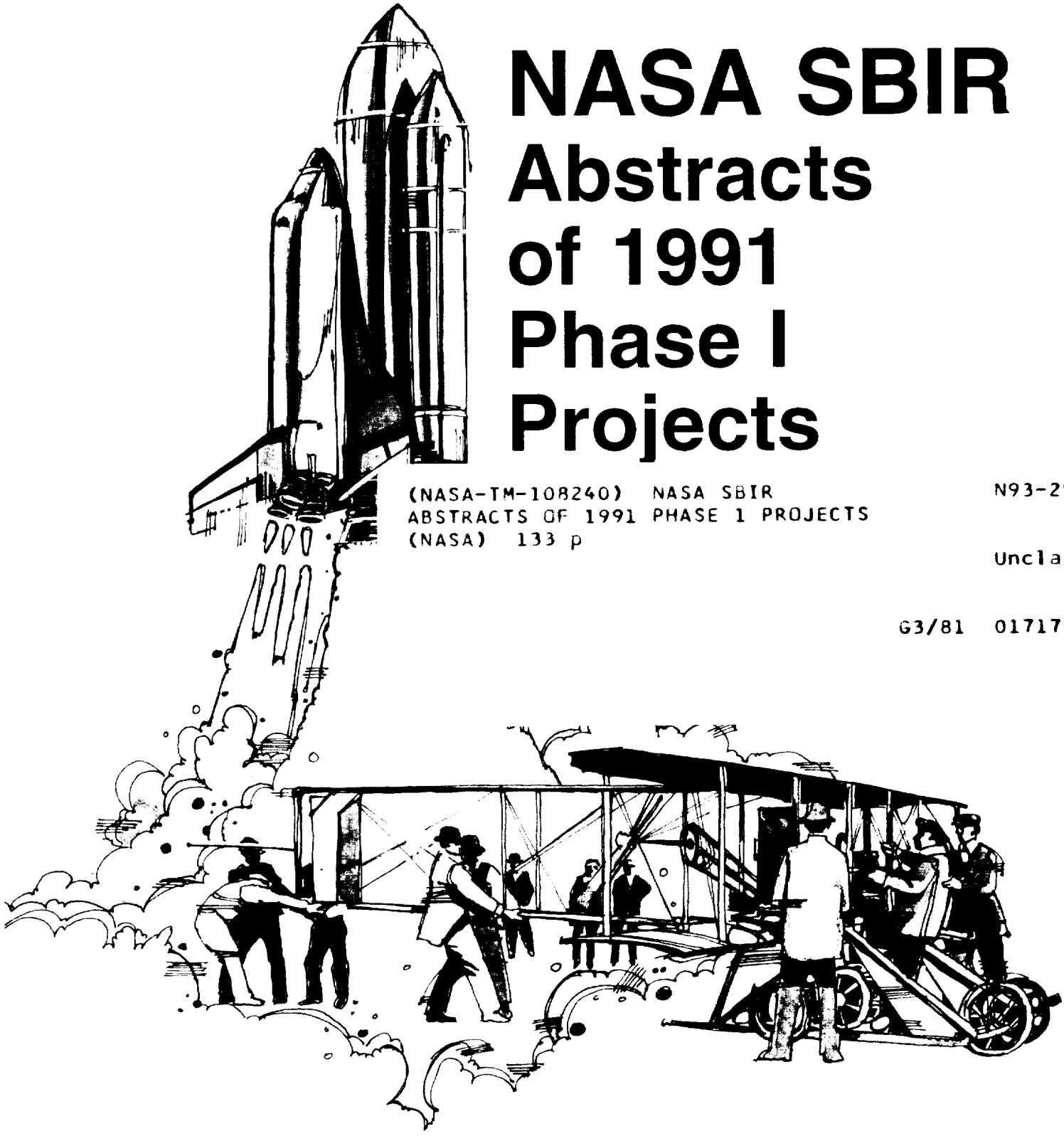

NASA SBIR Abstracts of 1991 Phase I Projects

(NASA-TM-108240) NASA SBIR ABSTRACTS OF 1991 PHASE 1 PROJECTS (NASA) 133 p

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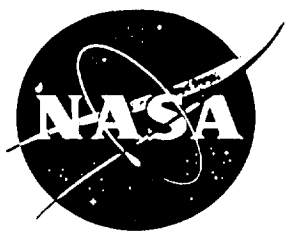
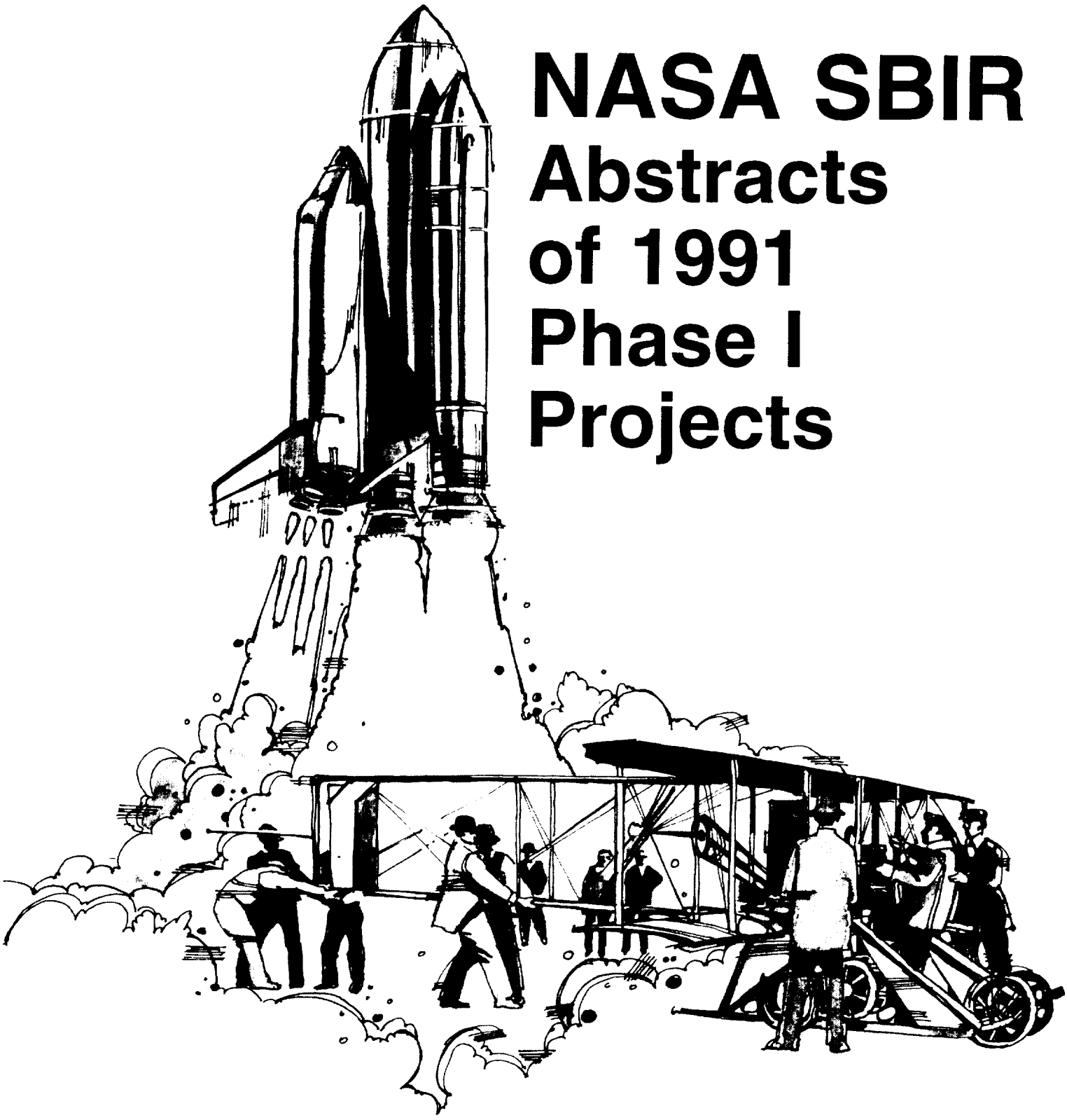


Small Business Innovation Research Program
Washington, DC 20546

Prepared for the Small Business Innovation Research Office, Office of Commercial Programs, National Aeronautics and Space Administration, by F. C. Schwenk, J. A. Gilman, and J. B. Paige of Futron, Inc., Bethesda, MD.

September 1992

NASA SBIR Abstracts of 1991 Phase I Projects



Small Business Innovation Research Program
Washington, DC 20546

Introduction

Objective

This document, *Abstracts of 1991 Phase I Projects*, describes the objectives of 301 projects placed under contract by the Small Business Innovation Research (SBIR) program of the National Aeronautics and Space Administration (NASA). These projects were selected competitively from among proposals submitted to NASA in response to the *1991 SBIR Program Solicitation*.

Contents

The basic document consists of edited, non-proprietary abstracts of the winning proposals submitted by small businesses. The abstracts are presented under the 15 technical topics within which Phase I proposals were solicited. Each project has been assigned a sequential identifying number from 001 to 301, in order of its appearance in the body of the report. The document also includes Appendixes to provide additional information about the SBIR program and permit cross-reference of the 1991 Phase I projects by company name, location by state, principal investigator, NASA Field Center responsible for management of each project, and NASA contract number.

The 1991 Phase I Projects

The closing date for the 1991 SBIR Phase I Program Solicitation was August 8, 1991, at which time 2583 proposals had been received. Following evaluation and selection of proposals for contract negotiation, 6-month fixed-price contracts were placed for 301 projects with 243 small businesses in 34 states to determine the feasibility of the proposed innovations. All projects were conducted during calendar year 1992. It is planned that approximately half of the successfully completed Phase I projects will be chosen in late 1992 and early 1993 for continuation into Phase II proposals.

Technical Topics

The order of abstract presentation is according to technical topics. Since 1984, each NASA SBIR Program Solicitation has contained the following fifteen technical topics:

01 Aeronautical Propulsion and Power
02 Aerodynamics and Acoustics
03 Aircraft Systems, Subsystems, and Operations
04 Materials and Structures
05 Teleoperators and Robotics
06 Computer Sciences and Applications
07 Information Systems and Data Handling
08 Instrumentation and Sensors
09 Spacecraft Systems and Subsystems
10 Space Power
11 Space Propulsion
12 Human Habitability and Biology in Space
13 Quality Assurance, Safety, and Check-Out for Ground and Space Operations
14 Satellite and Space Systems Communications
15 Materials Processing, Microgravity, and Commercial Applications in Space

Subtopics

Each technical topic contains a number of subtopics that specify the problems or opportunities to which small firms are invited to address Phase I proposals. The number and content of the subtopics change from year to year, depending on the interests of the agency. The SBIR Program Solicitation for 1991 included the 194 subtopics listed in Appendix B.

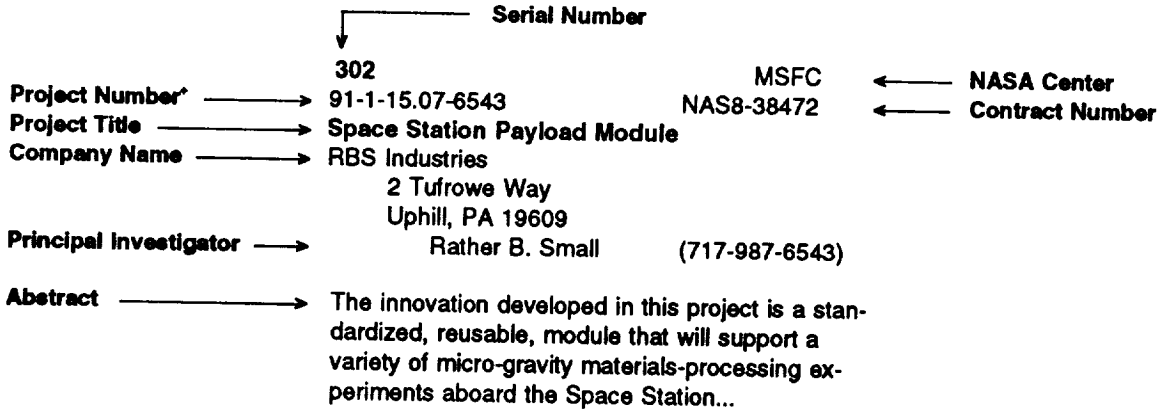
Program Management

Overall program management is provided by the Office of Commercial Programs in NASA Headquarters. NASA Field Installations noted in this document by the following designations evaluate SBIR proposals, place contracts to selected firms and manage individual SBIR projects:

- **ARC** Ames Research Center, Moffett Field, CA 94035
- **GSFC** Goddard Space Flight Center, Greenbelt, MD 20771
- **JPL** Jet Propulsion Laboratory, Pasadena, CA 91109
- **JSC** Johnson Space Center, Houston, TX 77058
- **KSC** Kennedy Space Center, FL 32899
- **LaRC** Langley Research Center, Hampton, VA 23665
- **LeRC** Lewis Research Center, Cleveland, OH 44135
- **MSFC** Marshall Space Flight Center, Huntsville, AL 35812
- **SSC** Stennis Space Center, MS 39529

Project Information

Each project description begins with the serial number and the project number. The project number is composed of the program year (91), the topic and subtopic numbers (15.07), and an identifying number (6543). The data is the most current available. In cases where firms have changed names or rights to Phase I results have been sold, the new name or owner is shown.



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Abstracts of NASA SBIR 1991 Phase 1 Awards

Small Business Innovation Research

Abstracts of 1991 Phase I Projects

01: Aeronautical Propulsion and Power

001 LeRC
91-1-01.01-4807 NAS3-26328
Multilevel Adaptive Methods for Combustion
Front Range Scientific Company, Inc.
Campus Box 170, P.O. Box 173364
Denver, CO 80217-3364
Chaogun Liu (303-556-4807)

This project's objective is to improve the accuracy and efficiency of numerical simulation for realistic combustion. It will also enhance the capability to solve three-dimensional, time-dependent, turbulent problems with chemical reactions using the application of parallel multilevel adaptive methods. These simulations are severely limited by the capabilities of currently available computers. The approach is based on a staggered grid, high-order finite-volume method and a fully implicit time-stepping scheme for better accuracy and stability. Also, a distributive relaxation multigrid method will accelerate the convergence process, a dynamic multilevel adaptive grid generation scheme will be used for local refinement, and the fast adaptive composite grid method will achieve high accuracy and efficiency for computation on the composite grid. The development will have parallel computation in mind to greatly enhance the capability to handle very large scale combustion problems.

Potential Commercial Applications: The software will be able to realistically simulate combustion. Applications would be in engine design and the reduction of emitted pollutants.

***

002 LeRC
91-1-01.01-6660 NAS3-26601
A Deformation Model for Producing Adaptive Grids
MDA Engineering, Inc.
500 East Border Street, Suite 401
Arlington, TX 76010
Ralph Noack (817-860-6660)

Using the concept of deformation of the cell volume, a design for adaptive grid generation will be developed. The advantage would be having guaranteed existence and uniqueness of the grids produced in both two and three dimensions when small distortions are assumed. A new, closed form solution of the deformation equation for large distortions has been developed. This large distortion solution will be used as an adaptive grid generator for a number of geometric examples and two-dimensional flow problems. Extensions of the existence and uniqueness theorems to the large distortion problem will be developed providing a sound theoretical basis for the new method.

Potential Commercial Applications: Commercial applications would be in the aerospace, automotive and chemical industries.

***

003 LeRC
91-1-01.01-9939 NAS3-26602
Transition and Heat Transfer in Gas Turbines
Dynaflow, Inc.
P.O. Box 21-319
Columbus, OH 43221-0319
G. Stuckert (614-487-9939)

This project's goal is to develop a technique for analyzing stability, transition, separation, and heat transfer in flows over turbine blades. The technique would use an extension of the parabolized stability equations that combine high computational efficiency with the unique capability to account properly for initial conditions, inhomogeneous boundary conditions, streamwise variations of the basic flow, curvature, and other effects on stability, transition, separation, and heat transfer. The parabolized stability equations and their successful application to two-dimensional incompressible flows are considered breakthroughs in transition research. Their extension to three-dimensional boundary layers on strongly curved turbine blades and to the unsteady disturbance environment is considered a breakthrough in both research tools for enhanced understanding of the complex flows in turbines and in engineering methods for gas turbine design. This method would provide more reliable transition and heat transfer data to predict and improve the efficiency of gas turbines.

Potential Commercial Applications: The completed design will be useful for applications requiring laminar flow control design, such as inlets and nozzles. The aircraft engine industry will benefit by the enhanced efficiency of gas turbines and the ability to analyze the heat transfer. It will also be helpful in the design of advanced aircraft.

***

004 LeRC
91-1-01.02-3000 NAS3-26333
Fuel-Rich Catalytic Combustion
Catalytica, Inc.
430 Ferguson Drive
Mountain View, CA 94043-5272
James C. Schlatter (415-960-3000)

This project's objective is to develop a novel catalyst system for oxidizing liquid hydrocarbon fuels under fuel-rich conditions and to explore the feasibility of fuel-lean operating conditions. Such a catalyst is a key component of a NASA low-emissions aeropropulsion turbine concept for advanced, high-speed, civil transport aircraft. The turbine combustor would operate with two stages: a catalytic section to initiate oxidation of the fuel in a fuel-rich mixture, and, after addition of excess air, a homogeneous combustion zone to complete the oxidation of the fuel. Experimental studies at NASA have shown some promise for this approach, but the catalyst performance has not been adequate. Phase I will evaluate, in detail, the results of the NASA experiments. A research effort to obtain an understanding of the critical factors in the aeropropulsion application will then take place. Then recommendations for improved formulations and configurations for future testing will be considered.

Potential Commercial Applications: The ultimate goal is a novel, low-emissions catalyst system that can be applied to a gas turbine propulsion unit for high-speed, civil transport aircraft. Its impact on the world's future transportation systems would be of major proportions.

***

005 LeRC
91-1-01.03-0333 NAS3-26334
Compressor Stall Avoidance and Alleviation
Scientific Research Associates, Inc.
P.O. Box 1058
Glastonbury, CT 06033
John P. Kreskovsky (203-659-0333)

This project addresses development of a system for avoiding and controlling compression system instabilities in gas turbine engines. Phase I will assess the feasibility of analyzing engine data to identify a stall precursor in the time scales required for real-time corrective action. The precursor is a growing small-amplitude traveling wave. When no precursor is identified, a backup stall detection system and active control system would be used. Phase I will include a feasibility assessment, development of real-time software, demonstration of the procedure on existing data for stall without inlet distortion, and a plan for high-speed component testing. Phase II will develop the hardware and software for stall avoidance and demonstrate and evaluate the innovation through an existing component test program. The project will demonstrate that real-time, stall precursor detection and active control can be used for stall avoidance to significantly improve engine operability.

Potential Commercial Applications: A detection/control system for use in avoiding compressor instabilities will significantly reduce current compressor stall margins and requirements thereby providing a important gas-turbine technology that will be marketed to gas-turbine manufacturers. The signal analysis technology will be marketed for other applications.

***

006 LeRC
91-1-01.03-0900 NAS3-26599
Hexagonal-Silicon-Carbide Crystal Pressure Sensors for High-Temperature Applications
Kulite Semiconductor Products, Inc.
One Willow Tree Road
Leonia, NJ 07605
Anthony D. Kurtz (201-461-0900)

Currently, pressure sensors capable of functioning at temperatures above 500°C are not commercially available. This innovative technology will allows pressure measurements to 800°C by using 6H-SiC resistors as piezoresistive sensing elements in monolithic SiC pressure transducers. Development of novel semiconductor processes will enable fabrication of micro-electromechanical transducer structures in SiC. This transducer will address the need for highly durable, precise sensors to operate in the high temperature portions of advanced aerospace propulsion systems and wind tunnels. Pressure measurements at these temperatures will be useful for the design and operation of such systems. Phase I will be devoted to the characterization of the piezoresistive properties of 6H-SiC as well as new electrochemical micromachining process developments that will enable the fabrication of thin, single-crystal SiC diaphragm structures. This will demonstrate if 6H-SiC can be used as a force collector and sensing element, thereby determining whether monolithic transducers can be fabricated in SiC. Phase II will develop and test high-temperature SiC pressure transducers for aerospace applications.

Potential Commercial Applications: Pressure transducers that can provide precise measurements in the high temperature portions of compressors, turbines and jet engines have wide applicability in commercial as well as military aircraft. Improved measurements enhance performance, safety and fuel efficiency.

***

007

91-1-01.03-9500 LeRC NAS3-26600

Turbomachinery Temperature Measurements Using an Oxygen-Laser-Induced Fluorescence

Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
Kurt D. Annen (508-663-9500)

Recent progress in designing advanced turbomachinery includes the use of numerical models of compressors, turbines, and combustors to guide new designs. However, further advancements in the accuracy of numerical models are needed. Improvements in these models will depend significantly on the availability of quality experimental data against which the models can be judged. Velocity data currently being acquired in compressor and turbine test facilities needs to be accompanied by temperature measurement to improve the utilization of the data by numerical modelers and to allow the determination of the heat transfer coefficient and Stanton number from heat flux measurements. This project will develop a diagnostic tool using 0_2 laser-induced fluorescent (LIF) and 0_2 Raman scattering to perform linear-imaging gas temperature measurements in turbomachinery. The ratio of the 0_2 LIF signal to the 0_2 Raman signal is a function of temperature only, and is independent of the laser power and the cleanliness of the optics. Seeding is not required. Single pulse measurements of the temperature profile can be performed with good precision. Phase I will determine the optimum laser excitation wavelengths for measurements in compressor and turbine test facilities. The temperature sensitivity of the technique will be measured and compared with theoretical predictions. A system for turbomachinery applications will be designed and the accuracy and precision of the temperature measurement system will be calculated.

Potential Commercial Applications: The turbine temperature measurement system will have commercial applications for temperature and heat transfer coefficient measurements in turbomachinery test facilities of jet engine and stationary power turbine manufactures.

***

008

91-1-01.04-7970 LeRC NAS3-26331

Advanced Photochemical Techniques for Relight and Combustion Enhancement of Supersonic Transport Aircraft Systems

ML Energia, Inc.
P.O. Box 1468
Princeton, NJ 08542
Moshe Lavid (609-799-7970)

Successful operation of future supersonic aircraft propulsion systems depends on the attainment of significant advances in combustion technology. The conditions of high flight-speed and high altitudes cause severe strains on ignition reliability, stability, and overall combustion efficiency. A novel photochemical technique to alleviate these problems and selectively irradiate combustion species will be developed. The ensuing photodissociative reactions generate highly reactive radicals that modify the gas-phase kinetics and lead to ignition and enhancement via chain-branching paths. The overall objective of Phase I will be to determine, experimentally, the feasibility of using this technique to obtain reliable relight of Jet A fuel. Specific tasks in this effort include investigating minimum ignition energy, power requirements, flow conditions, radiant frequency, and reliability. The effect of this technique on ignition-delay-time may also be investigated.

Potential Commercial Applications: This innovation might lead to a breakthrough in gas turbine combustion technology by substantially improving the performance of engines to extend the range and speed of supersonic aircraft for commercial and military applications.

***

02: Aerodynamics and Acoustics

009

91-1-02.01-1515 ARC NAS2-13514

Fuzzy Grid Methods for Computational Fluid Dynamics

Cambridge Hydrodynamics, Inc.
P.O. Box 1403
Princeton, NJ 08542
Ilya Staroselsky (609-683-1515)

Grid generation for computational fluid dynamics (CFD) is a critically important field of technology. The fuzzy grid method is a novel way to generate simple and robust unstructured grids for the solutions of equations in very complex geometries. In comparison with the current state-of-the-art unstructured grid methods such as Delaunay/Voronoi grids, fuzzy grids are easier to apply to higher dimensional problems and have better stability properties. Many of the most important research questions today in computational fluid dynamics involve strongly inhomogeneous velocity fields, compressible turbulent flows, and shock waves. Such occurrences are found in regions of relatively smooth velocity fields interspersed with regions of high vorticity and high pressure gradients. This causes conventional structured grid techniques such as spectral element methods to be very wasteful in terms of computer time and storage. Unstructured grid techniques are a more efficient approach but have proven difficult to implement in high dimensions. Also, the complexity induced by the nonlocal interactions in the grid makes the analysis of their mathematical properties difficult. This innovative fuzzy grid technique is easy to implement on both vector and parallel supercomputers and its simplicity enables mathematical verification of important stability and convergence properties.

Potential Commercial Applications: The development of efficient, easy-to-use software is key to enabling the accurate, efficient solution of complex engineering problems in many areas. The fuzzy grid technique will have commercial interest because it will allow robust, accurate simulations of the most complex flows of industrial interest.

***

010 ARC
91-1-02.01-9457A NAS2-13515
A Mathematically Based Reynolds-Stress Model of Turbulence
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Robert E. Childs (415-968-9457)

Turbulence modeling is a critical element in most computational fluid dynamics calculations in all speed ranges, from subsonic to hypersonic. However, existing models are inadequate for large classes of flows. An example of this would be flows with large regions of separation and three-dimensional flows. The inadequacy of these turbulence models can be attributed to the heuristic reasoning that is used in the model derivation. The goal of this project is to develop a mathematically (as opposed to heuristically) based model that is self-consistent and from which error bounds can be deduced. The approach will use Duhamel's equation to derive an expression for the terms which must be modeled in normal Reynolds-stress transport models.

Potential Commercial Applications: Improved turbulence models will benefit aircraft and automobile manufacturers and chemical and food processors.

***

011 ARC
91-1-02.01-9939 NAS2-13513
Stability and Transition on Swept Wings
Dynaflow, Inc.
P.O. Box 21-319
Columbus, OH 43221-0319
G. Stuckert (614-487-9939)

A technique for analyzing stability and transition in supersonic flows over swept wings will be developed. It will use an extension of the parabolized stability equations that combine high computational efficiency with the unique capability to properly account for initial conditions, streamwise variations of the basic flow, curvature, and other effects on receptivity, stability, and transition. These equations and their successful application to two-dimensional incompressible flows are considered breakthroughs in transition research. The extension to three-dimensional boundary layers in supersonic flow over realistic geometry is an innovation in research tools for enhanced understanding of transition as well as in engineering methods for advanced aerodynamic design. This technique will provide reliable transition data to improve aerodynamic characteristics and optimize the design of advanced aircraft for high-speed civil transport. It will also allow evaluation of the different transition characteristics in laboratory tests and free flight.

Potential Commercial Applications: This technique has direct commercial applications in the aircraft industry to optimize the aerodynamic characteristics and efficiency of high-speed aircraft for civil or other transportation. It can also be adapted to the traditional commercial flight regime and will be valuable for the design of laminar-flow-control systems and gas turbines.

***

012 LaRC
91-1-02.02-7093 NAS1-19518
Suction Laminarization of Junctures in Laminar-Flow-Control Airplanes
Analytical Services & Materials, Inc.
107 Research Drive
Hampton, VA 23666
Werner Pfenninger (804-865-7093)

The range of transport airplanes has increased during the past years. When laminar flow is achieved over most of the aircraft surface, they will have even longer range. This is because laminar-flow-control (LFC) will substantially raise the lift/drag ratio in cruise. This project will use distributed suction to maintain laminar flow in the particularly critical juncture region between the wing and fuselage. In Phase I, the feasibility of this approach will be evaluated computationally. For a given wing-fuselage juncture configuration, boundary layer development and stability calculations will be used to determine suction requirements to maintain laminar flow runs in the juncture region. Configuration geometry tailoring in the juncture near the wing trailing edge will achieve fuselage laminarization downstream of the wing trailing edge. Phase I will evaluate the performance improvement due to suction and Phase II will conduct a wind tunnel experiment to demonstrate the innovation.

Potential Commercial Applications: This novel approach can be used to design junctures between various components in LFC airplanes.

***

013 LaRC
91-1-02.03-2036 NAS1-19551
Navier-Stokes Technique for Aerobraking Orbital-Transfer Vehicles
VRA, Inc.
P.O. Box 50
Blacksburg, VA 24063
Clark H. Lewis (703-953-2036)

Upon atmospheric entry, proposed aerobraking orbital-transfer vehicles (AOTV) configurations will experience large heat loads. Accurate prediction of

these complex flow fields is necessary for designing appropriate heatshields. Thermal-chemical nonequilibrium, nonequilibrium radiation, and surface-ablation effects will be important under these conditions. This project will develop and demonstrate a new space-marching Navier-Stokes scheme that will be computationally fast and efficient and will also be able to address these flow-field effects. Phase I will focus on axisymmetric perfect-gas flow over a typical AOTV forebody, and will use a space-marching approach with Van Leer flux splitting. The project will demonstrate this new numerical capability by predicting hypersonic flow over a 70-degree sphere-cone under typical AOTV conditions, and provide a detailed engineering report. Phase II will address the extensions to include three-dimensional flows, a wide range of nonequilibrium-to-equilibrium flows, radiation and surface-ablation effects, and will include near- as well as far-wake flow field regions. The developed code(s), user's manual(s), and a final engineering report will be provided at the end of Phase II.

Potential Commercial Applications: Commercial applications include the design and analysis of various hypersonic penetration aids and decoys, NASP, TAVs, AOTVs and aerobrakes, and AFE configurations. In the absence of sufficient flight data, these computational fluid dynamics capabilities will help generate the data base for such advanced design concepts.

***

014 LaRC
91-1-02.03-3844 NAS1-19524
Numerical Simulation of Hypersonic, Shock-Separated Flows in a Turbulent Medium
DCW Industries, Inc.
5354 Palm Drive
La Canada, CA 91011
David C. Wilcox (818-790-3844)

Using the multiscale model of turbulence devised by Wilcox, an analytical/numerical method will be applied to investigate hypersonic shock-separated flows in a turbulent medium. This project will incorporate the multiscale model in a NASA Langley three-dimensional thin-shear-layer computer program known as CFL3DE and provide for high Mach number corrections for the turbulence model using a combination of physical reasoning aided by analytical and numerical tools. A key phenomena pertinent in hypersonic flows, viz, strong compressibility effects, compressible viscous sublayer and defect layer structure, and heat-transfer effects will be addressed. Hypersonic viscous-inviscid interactions will then be numerically simulated. The computations will determine how well the multiscale model predicts properties of such flow and if it is feasible to use a second-order-closure model for three-dimensional computations with today's computer resources.

Potential Commercial Applications: This project may lead to a greatly improved capability to predict properties of turbulent flow in incompressible through hypersonic speed ranges. This could help reduce fuel consumption for airplanes, ships, automobiles, etc.

***

015 ARC
91-1-02.03-3921 NAS2-13554
Basic Governing Equations and Physical Models for Highly Nonequilibrium Hypersonic Flows
BSA Services
4010 Tidewater
Houston, TX 77045
Jong-Hun Lee (713-433-3921)

This project will investigate the use of a four-temperature concept for highly nonequilibrium hypersonic flows. The development of hypersonic space vehicles for future NASA missions involves knowledge of complex aerothermodynamic phenomena such as thermal and chemical nonequilibrium. Since it is extremely difficult to simulate the thermochemically complex flow field around vehicle models in a ground-based experimental facility, it is highly desirable to obtain accurate numerical computations of the flow field. To do so, it necessary to have a physically valid set of conservation equations in the flow regimes of interest. The objective of this project is to develop a basic set of governing equations and physical models based on the concept of four independent temperatures (translational, rotational, vibrational-electronic, and electron temperatures), for the highly nonequilibrium hypersonic flows around future space vehicles. A phenomenological approach will be taken to clarify the technical issues to be resolved and to examine possible engineering methods to attack the issues. This comprehensive analysis of expected thermochemical nonequilibrium phenomena proposed for Phase I will provide the basis for further development of the detailed physical models. Phase II will incorporate these models into the required set of basic governing equations.

Potential Commercial Applications: This work will establish the theoretical feasibility of phenomenological models in the highly nonequilibrium hypersonic flow around future space vehicles and planetary probes. The governing equations and physical models obtained may become the basis for future development of computational fluid dynamics codes that will be used in the design of proposed space vehicles and planetary probes.

***

016 ARC
91-1-02.03-6100 NAS2-13560
High-Speed Velocity Diagnostic for Arc Facilities
Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303
Anthony O'Keefe (415-493-6100)

Thermal protection of the outer structure of a space vehicle during atmospheric re-entry is crucial to the success of that vehicle's mission. The effects of spacecraft heating due to gas in the earth's upper atmosphere can be simulated in the laboratory using an arc jet flow. The need for accurate analysis of such data is critical since the amount of thermal shielding loaded onto a spacecraft directly impacts the payload. Laser induced fluorescence techniques are being developed to probe for species content and temperature in these flows. The goal of this project is to develop a fast (kHz) remote probe of flow velocity in arc-flow research facilities. This innovation will permit the velocity field to be mapped out with both spatial and temporal resolution, allowing detailed analysis of turbulence and shock front effects. Preliminary physical and optical measurements will be used to evaluate the potential of this approach.

Potential Commercial Applications: This project will establish the feasibility of making high speed flow velocity measurements with a non-intrusive laser probe. Applications include use in the development of advanced air frames, high speed jet engines and rockets and in the remote measurement of engine thrust.

***

017 ARC
91-1-02.04-9090 NAS2-13553
A Novel Coupling Technique for Solving the Euler Equations Over Complete Aircraft
Analytical Methods, Inc.
P.O. Box 3786
Bellevue, WA 98009
David M. Tidd (206-643-9090)

To increase the design throughput of complex full aircraft configurations, a method which is both computationally efficient and has minimal setup time is required. This project will develop a new procedure for coupling a cartesian, multigrid Euler code with a second Euler technique using a body-filled mesh. The method, coupled with an iteration scheme, combines the advantages of two different gridding techniques to produce a resulting scheme which will facilitate rapid model setup. The research is aimed at providing a practical Euler method for complete aircraft configurations including nozzle afterbody and inlet integration studies.
Potential Commercial Applications: This novel technique would lead to an improved design capability for complex aircraft, including a faster throughput of design and reduced amount of wind tunnel testing.

***

018 LaRC
91-1-02.05-9457A NAS1-19529
A Prediction Method for High-Angle-of-Attack Aerodynamics
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Patrick H. Reisenthel (415-968-9457)

The occurrence of structural failures of the vertical tails on aircraft such as the F-15, F-18, and possibly the F-22 is a problem of extreme importance. These failures are due to aerodynamic interaction between the vertical tail and the unsteady vortical flow. In order to avoid this adverse interaction it is necessary to predict the flow in the early design stages so that appropriate steps can be taken. The key element in predicting the unsteady airloads on the tail of an aircraft at high angles-of-attack is a model of the vortex that emanates from the forebody, inlet, or leading edge extension. This model should be capable of representing a burst vortex. The overall model of the flow field could then be used to analyze the loading on the tails. Predicting the unsteady flow that causes the failure of the tails will be explored. The goal of this project is to produce an engineering tool for high angle-of-attack flows significantly beyond the onset of stall by applying the simplest possible physical models.

Potential Commercial Applications: This engineering methodology and a prediction tool would help designers ensure that the fatigue problems occurring on twin-tail tactical fighters do not arise in future aircraft designs. This will be of considerable benefit to the federal government and to the aerospace industry.

***

019 ARC
91-1-02.06-7722 NAS2-13534
Simulation of Helicopter Rotor-Body Interaction Flow Fields by Navier-Stokes Method
JAI Associates, Inc.
465 Fairchild Drive, Suite 111
Mountain View, CA 94043
G.R. Srinivasan (415-967-7722)

A three-dimensional, unsteady Navier-Stokes numerical methodology to calculate economically and accurately the flow field of multi-bladed helicopter rotor and fuselage in hover and forward flight will be developed. Ad hoc wake models will not be used to model the vortex wake; instead, the complete vortical wake will be captured as a part of the overall flow field solution. A Navier-Stokes upwind scheme will be used in conjunction with a Chimera grid for preserving and convecting concentrated vortices. Phase I will demonstrate a calculation for a rotor-body combination in hover which would provide a solid foundation for realistic calculations in hover and forward flight in Phase II. The individual items to be completed in Phase I are the gridding of a two-bladed rotor and fuselage for a Chimera scheme;

implementation of Chimera and Pegasus schemes into the Navier-Stokes numerical method; and a demonstration calculation of rotor-body flow in hover and comparing the results with experiments.

Potential Commercial Applications: Commercial applications include the design of advanced technology helicopters with efficient aerodynamics and aeroacoustics performance, including the selection process of rotor blade shapes and planforms and the interaction of multiple moving bodies relative to each other such as the main rotor and tail rotor and engine turbines and compressors.

***

020 LaRC
91-1-02.07-6621 NAS1-19517
Long-Wavelength, Infrared, Detection System for Wind Tunnel Design and Experimental Techniques
Amber Engineering, Inc.
5756 Thornwood Drive
Goleta, CA 93117-3802
John D. Blackwell (805-683-6621)

Infrared detection and imaging systems are required for measuring temperature profiles along the surface of models in a cryogenic environment, down to 100 K or less. Staring infrared arrays offer advantages over scanned arrays presently used for this application. This project will demonstrate the feasibility of installing a closed-cycle infrared camera system in a wind tunnel. The firm has successfully demonstrated gallium-doped silicon (Si:Ga) 128x128 element, long-wavelength infrared (LWIR) staring focal plane arrays (FPAs), with spectral coverage from 3-17 micrometers. A Si:Ga based LWIR imaging system will be used to image airplane models. A sensitivity of 0.02mK or better is predicted for Si:Ga at temperatures down to 100 K. The system's video electronics features variable frame rates (up to 217Hz) and integration times, and furnishes both raw digital data and RS-170 outputs for data recording purposes. It is anticipated that project results will show Si:Ga staring FPA technology is the optimal solution for test and research applications in cryogenic windtunnels. This project offers the near-term prospect of retrofitting wind tunnels with low-cost, high-performance LWIR camera systems.

Potential Commercial Applications: Commercial applications would apply in leak detection and imaging or similar low background scenes including satellite detection, detection of clear-air turbulence (commercial aircraft), discovery of leaks in pipelines (e.g., Alaska oil pipeline), constituent determination of earth and planetary atmospheres, and remote sensing of atmospheric and weather conditions.

***

021 LaRC
91-1-02.07-9200 NAS1-19537
Power Generation Source for Electrothermal Wind Tunnel
Princeton Combustion Research Laboratories, Inc.
4275 U.S. Highway 1
Monmouth Junction, NJ 08852
Martin Summerfield (609-452-9200)

This project investigates the main problems involved in the design of a short-duration electric generator for powering an electrothermal-type of high-speed wind tunnel, Mach 10-20, for aerodynamic and combustion research. The design objectives are to discharge and transfer 150 MJ of energy to liquid air for a duration of the discharge of 300 msec. The generator is visualized as a specially-designed piston of 0.5 meters diameter, driven along a straight tube through a magnetic field of 2 tesla at a velocity of 120 m/sec. The drive source is a smokeless solid propellant combustor having a burn-up time equal to about 300 msec and dimensions of 1.3 meters long and 0.6 meters outside diameter. This project will perform the needed computations and design study to explore the feasibility of the electromagnet for creating the desired field; design the special piston; design the special electrodes required to collect the power output; and determine the best design of the solid propellant charge.

Potential Commercial Applications: This short-duration electric power source is specially aimed at electrothermal wind tunnels. Whether it has any eventual commercial application will be determined by the design characteristics of the electric generator.

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022 LaRC
91-1-02.08-0003 NAS1-19534
A Quantitative Skin Friction Imaging Sheet
Physical Sciences, Inc.
20 New England Business Ctr
Andover, MA 01810
R. Daniel Ferguson (508-689-0003)

Optical techniques have been employed in attempts to gain a qualitative picture of the skin friction distribution over surfaces. The methods based upon coatings which exhibit shear-stress-sensitive properties have limited dynamic range. They require external imaging systems that render them less suitable for aeronautical applications. New thermal-type imaging approach offers the potential of high-resolution, CCD-style readout and display of skin-friction data in real time without the need for external optical diagnostics, and will be developed for large-area (~1 m^2) wind-tunnel instrumentation and aeronautical applications. The proposed device would consist of an array of a new type of thermal, shear-stress sensor integrated into a thin, flexible skin. High-sensitivity, flexible, pyroelectric sensors that accumulate charge in proportion to local temperature changes can monitor local surface cooling rates after known heat

pulses are delivered by underlying heating films. This cooling rate has a simple relationship to the skin friction. Standard "V"-type sensor configurations can separate the wall shear stress components in cross-flow conditions. The skin friction would read out in a manner similar to CCD-array cameras. Such a sheet could be readily attached to any surface and the skin friction monitored and displayed continuously in, for example, standard RGB video format.

Potential Commercial Applications: A non-intrusive, skin-friction CCD 'camera' has the potential to become a commercial product usable in fluid dynamics laboratories around the world. These distributed sensor arrays can be installed on aircraft wings with outputs coupled to control system which improve aerodynamic performance. Active control strategies can be developed for turbulence, flow separation and cross-flow problems, where rapid assessment of extended flow-field topology is critical.

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023 LaRC
91-1-02.09-4986 NAS1-19514
Reduction of Supersonic Plume Noise Through the Controlled Introduction of Axial Vorticity
Advanced Projects Research, Inc.
147 Ward Street
Hightstown, NJ 08520
Thomas H. Sobota (609-443-4986)

The use of axial vorticity generated in aircraft exhaust nozzles offers some interesting possibilities in the area of flow manipulation in order to reduce the noise radiated from the associated jets. This project suggests that the manipulation and placement of streamwise vorticity in the flow field will serve to significantly influence the noise radiation in the exhaust plume in two ways. The large scale coherent vortex structure of the exhaust jet can potentially be modified in order to reduce the noise radiation. Enhanced mixing caused by axial vortices will reduce the extent of the exhaust plume. This placement of vorticity has been demonstrated experimentally and numerically with numerical simulation predicting substantially increased mixing. Streamwise vorticity, resulting from residual swirl created by the engine turbomachinery, may be manipulated by nozzle wall contouring to produce well-defined streamwise vortices. Forcing the separation of the boundary layer that forms on the nozzle wall will manipulate existing vorticity in the flow to create axial vortices.

Potential Commercial Applications: The reduction of noise from commercial aircraft is of great interest to the air transport industry. Techniques for reducing aircraft noise have enormous commercial potential for both new aircraft and the retrofit of older aircraft.

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024 LaRC
91-1-02.09-9457 NAS1-19530
Methods for Computational Aeroacoustics
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Robert E. Childs (415-968-9457)

Computational aeroacoustics (CAA) is an emerging discipline in which numerical solutions of the partial differential equations governing compressible flow are employed to make predictions of the noise generated by unsteady and turbulent flows. Methods required for CAA are somewhat similar to those used in computational fluid dynamics (CFD); however, two major differences are that CAA requires significantly better far-field boundary conditions and higher accuracy solution algorithms than are typically employed in CFD. Innovative boundary conditions which employ superposition of numerically generated solutions for the exterior of the computational domain will be developed to treat difficult outflow problems. A high-order-of-accuracy shock-capturing algorithm will be constructed to be consistent with the laws of thermodynamics, unlike many shock capturing schemes. Improvements in computational efficiency (interpreted as the range of scales resolved per computational cost) as large as two orders of magnitude when compared to existing second order methods may be achieved.

Potential Commercial Applications: This project will improve accuracy and/or reduce cost for computational methods, both CAA and CFD. These methods are employed by a range of businesses that are as diverse as aircraft, automobile, and ship manufacturing, food processing, and biomechanics firms. All of these areas, especially the aerospace industry, could benefit.

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025 LeRC
91-1-02.10-1421 NAS3-26598
Aeroacoustic Diffraction and Dissipation by a Short Propeller Cowl in Subsonic Flight
Cambridge Acoustical Associates, Inc.
80 Sherman Street
Cambridge, MA 02140
Rudolph Martinez (617-491-1421)

This project will investigate two concerns of the propfan noise research program: the beneficial effect of placing the new propulsion system within a short, diffractive cowl and whether practical variations in the configuration of the acoustic liner on such a cowl would significantly affect the character of the noise emerging from its ends. A ducted-propeller theoretical model will be developed incorporating the following physical features: an idealized cowl of finite length, open-ended, unflanged, and thin-walled; an axisymmetric liner that will cover parts of its interior surface with variable material properties along the cowl's short axial extent; the effects of a subsonic freestream (the flight speed)

on the coupled phenomena of edge diffraction and liner dissipation and on the propagation of the predicted radiated field; and an insonifying aeroacoustic field due to a realistic distribution of modeled propeller sound sources.

Potential Commercial Applications: The design of acoustic liners specially tailored to short-ducted propellers will address, respectively, the problems of cabin noise during flight (near-field radiation patterns) and community environmental noise (far-field radiation patterns).

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026 LeRC
91-1-02.10-2585 NAS3-26326
Noise Reduction by the Dynamical Entrainment of Aircraft Engine Acoustics
Advanced Projects Research, Inc.
5301 North Commerce Avenue, Suite A
Moorpark, CA 93021
James D. Sterling (805-523-2585)

A novel method for the reduction of noise in propulsion systems will be developed. Pressure oscillations associated with engine internal flow dynamics will be analyzed using nonlinear dynamical systems theory to determine the effective number of degrees of freedom that participate in the oscillations. Reduction of this dimension can be achieved by nonlinear forcing of the system to achieve "mode-locking" or "entrainment" of the oscillations so that low-dimensional deterministic dynamics are obtained. Both linear and nonlinear control techniques may then be applied to the system to reduce or modify the attractor. Phase I will demonstrate the entrainment of high-dimensional dynamics onto low-dimensional attractors for known mathematical constructs; apply dimension-determination techniques to the results of acoustic models to characterize "noisy" data; and investigate the application of dimension reduction techniques to acoustic oscillations associated with rotor-stator interactions, nozzle acoustic-entropy interactions, combustion chamber acoustic modes, and compressor surge.

Potential Commercial Applications: The reduction of noise by nonlinear entrainment of the high-dimensional dynamics may prove beneficial for many engineering systems. Application to propulsion systems requires hardware that can influence the fluid flow to reduce noise. It is anticipated that commercial implementation of the methods will first be applied to minimize pressure oscillations in combustors of aircraft engines.

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03: Aircraft Systems, Subsystems, and Operations

027 LeRC
91-1-03.01-8581 NAS3-26322
Surface Roughness Features Formulation for Aircraft Icing
Remtech, Inc.
3304 Westmill Drive
Huntsville, AL 35805
Robert D. Kirchner (205-536-8581)

A theoretical model will be devised to define icing surface roughness features in detail. The establishment of such a roughness model is crucial to the development of all future ice accretion models and ice scaling laws, and it is vital in efforts to gain a full understanding of the ice accretion process. The model will be derived from an analysis of physical mechanisms that govern the icing process, and it will define the texture of accreting ices in terms of the size, shape, and surface density of individual roughness elements that form during icing processes. One goal of this project is to provide the aviation industry with a tool that can be used to model the effects of roughness in surface heat transfer studies. Another is to help define the aerodynamic penalties associated with icing processes and so serve as an indispensable key in the development of all future ice accretion models and ice scaling laws.

Potential Commercial Applications: This project will provide a significant advancement in efforts to develop ice accretion models and ice scaling laws that can be used to establish the extent, growth rate, and effects of icing processes on aircraft surfaces in all icing conditions.

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028 LeRC
91-1-03.01-9457A NAS3-26321
Ice-Accretion Prediction on Massively Parallel Computers
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Steven C. Caruso (415-968-9457)

This project addresses the use of massively parallel computers for the prediction of time-dependent ice accretion on two- and three-dimensional aerodynamic bodies. Currently, the LEWICE computer code is being developed at NASA's Lewis Research Center for the prediction of aircraft aerodynamic performance under icing conditions. There are several distinct components to the LEWICE program, including water droplet trajectory calculations and airfoil aerodynamics predictions. These components can require large amounts of CPU time. The extension of this computer code to three-dimensional geometries will be severely restricted by the computational power of present-day single- or serial-

processor computers. The goal of this project is to demonstrate the feasibility of using massively parallel processing techniques to gain significant computational efficiencies for typical calculations performed in time-dependent icing analyses. In Phase II, the complete LEWICE code will be ported to a parallel computer.

Potential Commercial Applications: An accurate and efficient tool that can perform three-dimensional aircraft icing analyses could be used by both government and industry to further understand aircraft icing problems, decrease development time and costs of ice protection systems, and aid in the qualification and certification of aircraft to operate under icing conditions.

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029 LaRC
91-1-03.02-4545 NAS1-19549
A System for Tracking and Predicting the Motion of Aircraft Trailing Vortices
Technology Integration & Development Group, Inc.
54 Middlesex Turnpike
Bedford, MA 01730
George P. Succi (617-275-4545)

All aircraft generate a pair of trailing vortices, that pose a hazard to following aircraft. Large aircraft spacings are necessary to prevent hazardous wake vortex encounters. The increased separation results in reduced airport capacity. An aircraft wake monitoring system to track and predict the location of these vortices will be designed. The system is composed of three functions: an information monitor based on the firm's airport noise and operations monitoring system; wake tracking using an advanced planar-array, monostatic acoustic antenna; and prediction of the location of the wake vortices given local meteorological conditions. Each prediction will be displayed in real time on a map of the airport, along with an error bar, comparing the measured and predicted location of previous wakes. The innovation consists of the integration of these capabilities and in the advanced planar antenna.

Potential Commercial Applications: This system would be used as a vortex advisory system for airports.

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030 LaRC
91-1-03.03-2281A NAS1-19547
Eclectic, Mixed H-Infinity and Mu-Synthesis Procedures for Practical Flight-Control-System Design
Systems Technology, Inc.
13766 South Hawthorne Boulevard
Hawthorne, CA 90250
Peter M. Thompson (213-679-2281)

Modern aerospace vehicles require highly integrated multidisciplinary control systems and the use of numerous control effectors, including thrust vecturing. The resultant complexities motivate a need for improved synthesis methods and a re-examination of conventional control design criteria. The h-infinity optimal control approach is a promising candidate because performance and robustness specifications can directly be included in the cost function. As it now stands, h-infinity is not yet useful for flight control design and, indeed, has as many deficiencies for such purposes as it has promises. To overcome the major deficiencies, an eclectic and complementary mix of control synthesis procedures that utilize h-infinity and μ-synthesis as core techniques will be developed. The approach will address and rectify the deficiencies and evolve a practical composite technique for flight control purposes. The project will investigate the mixture of techniques and apply them to advanced stability augmentor and autopilot designs for a high-performance, high-angle-of-attack aircraft.

Potential Commercial Applications: The advanced practical synthesis methods developed could become universal in the design of advanced, highly integrated, robust flight control and similar automated systems in air, space, and ground transportation. Near-term possibilities include experiments on the NASA HARV, or applications to the X-30 or HSCT. Some of the techniques and procedures developed could be incorporated as upgrades in existing commercially available software design programs ("Program CC").

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031 ARC
91-1-03.04-1567 NAS2-13524
Parallel Implementation of Image Correspondence Algorithms for Rotorcraft
Innovative Configuration, Inc.
9053 Soquel Drive, Suite 203
Aptos, CA 95003
Vason Srini (408-688-1567)

The operation of rotorcraft in high-threat environments requires assistance from on-board computers, image sensors, and automation tools so that nap-of-the Earth flight mode can be used to carry out a specified mission. The goal of this project is to evaluate four parallel architectures for their ability to provide real-time obstacle detection, range estimation, image correspondence, and other near-field guidance calculations. The first architecture uses Datacube's MaxVideo 20 pipeline image processing system, containing multiple functional units interconnected by a 32 x 32 crossbar. The second architecture uses Intel/CMU's iWarp chip interconnected in a systolic manner. The third architecture involves general purpose microprocessors such as Sparc interconnected using a shared bus to form a shared memory multiprocessor. The fourth architecture employs special purpose, high-performance VLSI chips interconnected in a systolic manner. The four architectures will be evaluated using the algorithms and C programs available from NASA and other agencies during Phase I. These evaluations will determine what

portion of the parallelism present in the algorithms can be turned into speedup by the architecture. The features of each of the four architectures such as communication network, speed of ALU and multiplier, and pipelining that can facilitate the exploitation of parallelism into speedup will be analyzed and documented. Based on these evaluations, one of the architectures will be selected for implementation in Phase II. The implementation will result in a board that can be plugged into the SBUs slots of SparcStation 2 and experimented at NASA facilities.

Potential Commercial Applications: The compact and low-cost board can be used in spacecraft and ships. The system can also be used in full-motion video processing systems. The range estimation and image correspondence algorithms will be applicable in controlling robots, monitoring flow of materials in factories, and manufacturing.

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032 ARC
91-1-03.05-2100 NAS2-13439
A Three-Component, Optical, Doppler Air Velocity Sensor
Optra, Inc.
66 Cherry Hill Drive
Beverly, MA 01915
Geert Wyntjes (508-921-2100)

This project will assess the feasibility of a novel approach to a non-intrusive measurement of the relative, with respect to the vehicle, air velocities in the forward, pitch, and yaw directions using a radically different implementation of a laser Doppler anemometer. Unique to this design is a single beam for illumination with three interferometric receivers to measure the phase shift of the backscattered light in three vector directions. The combination of these will provide a measurement of air velocity in the forward, pitch, and yaw directions at a single point in space. Key to the design are the uses of a complex spatial filter to enhance fringe contrast and an efficient signal processor operating in the polar or phase domain to recover accumulated phase shift (proportional to the product of vector air velocity and time) with a low probability of error even when fringe signal-to-noise is low. The interferometric design can be implemented at any wavelength from the UV to well into the near-IR and makes only moderate demands on temporal and spatial coherence of the illuminating source, permitting consideration of both relatively broadband sources and spatial, multi-mode laser sensors. As envisioned, the sensor would be compact, weigh little, and require minimum electrical power.

Potential Commercial Applications: The sensor concept will satisfy many long-standing needs, including the measurement of air motions under extreme flight conditions. It will also extend the stand-off distance for the premonitory detection of low-altitude windshear.

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033 LaRC
91-1-03.05-7093 NAS1-19519
A Non-Intrusive, Solid-State, Angle-of-Attack Instrument
Analytical Services & Materials, Inc.
107 Research Drive
Hampton, VA 23666
S. M. Mangalam (804-865-7093)

A new technique for indicating the angle-of-attack (AOA) based on accurately locating the leading-edge stagnation point in flight will be developed. Advanced flow diagnostics techniques and instrumentation developed recently by the company will be used for the flight application. The stagnation point location will be determined by identifying the phase reversal signatures, and the clearly identifiable fundamental and higher harmonic dither frequencies in signals from micro-thin, multi-element, hot-film sensors. The multi-element, hot-film sensors will be operated by a high sensitivity constant voltage anemometer. Signals from 16 anemometers will be simultaneously acquired by the company's data acquisition and analysis system. Flight tests will be made on an experimental-class airplane to evaluate the feasibility of determining angle-of-attack over the entire flight envelope through the identification of the leading-edge stagnation point.

Potential Commercial Applications: Existing AOA devices are relatively high cost and/or intrusive. A low-cost, non-intrusive, digital relative angle-of-attack display suitable for general aviation aircraft as well as for transport and military aircraft has market viability, and could also be made available in a more sophisticated form to measure absolute AOA for research and flight test aircraft. The measurement technique can also be used to provide yaw or side slip angle displays as well as provide tail downwash or sidewash angles.

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034 LaRC
91-1-03.05-7637 NAS1-19520
Optical-Fiber Velocimeter for Flows in Hypersonic and Supersonic Flight
Candela Laser Corporation
530 Boston Post Road
Wayland, MA 01778
Rafael A. Sierra (508-358-7637)

A new airborne instrument for velocimetry of the external and internal flows of re-entry, hypersonic, and supersonic vehicles will be developed. This technique may also prove useful for temperature measurement. Based on the time-of-flight approach, the instrument uses laser-generated N_2 ions as tracers and delayed laser-induced fluorescence for imaging. Two recent

advances make this innovation possible: the identification of an efficient photo-ionization of N_2 and the development of a new burst-mode, Q-switched, frequency-doubled, Ti:Sapphire laser. The new laser can deliver two high-energy, tunable laser pulses using a single flashlamp pulse. The first pulse is used to write a tracer line by tuning it to the ionizing transition of N_2. The second pulse is used, after a preset delay, to induce fluorescence that is detected by a solid-state digital camera. The all-solid-state system is robust and may be made into a low-volume, low-power, minimally intrusive, highly accurate, and reliable device.

Potential Commercial Applications: This instrument will also be useful for wind tunnels and combustion diagnostics. In addition, the UV laser will find use as a resonance ionization source for mass spectrometric analysis of ultra trace elements in biological samples in medical research. Other applications of the laser include spectroscopy and materials research.

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035 ARC
91-1-03.05-8775A NAS2-13440
Synthetic, Moire-Fringe Surface Metrology
Bauer Associates, Inc.
177 Worcester Road, Suite 101
Wellesley, MA 02181
Paul Glenn (617-235-8775)

A new surface contour measurement will be developed. Because of its remote, non-contacting nature, it will be able to measure a wide variety of structural deformations, including those induced by high Mach number airflows over aerodynamic surfaces. The approach is an innovative variation on Moire fringe techniques. It replaces the physical, periodic viewing mask with specific digital image processing algorithms, making the approach easy to implement and extremely flexible. The result is accurate measurement data on a regular rectangular grid, with meaningful horizontal resolution equal to that of the viewing system. Sensitivities to deflections of several micro-inches and absolute accuracies better than one hundred micro-inches appear to be achievable. Objectives are to define a baseline system and to develop calibration algorithms and a comprehensive performance prediction model. Phase II will provide a breadboard instrument to characterize and demonstrate its capabilities. NASA applications include flight research sensors and instrumentation, as well as generalized surface metrology. Benefits include real-time, non-contacting, accurate measurement of surface shapes and deflections.

Potential Commercial Applications: Applications include in-process surface and deflection mapping of complex parts, including aerodynamic surfaces. The instrument can also be used for pre-weld shape and orientation inspection, mold inspection, part alignment in a robotic manufacturing cell, and measurement of human back shape for scoliosis screening.

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036 ARC
91-1-03.06-0533 NAS2-13458
Smart-Skin Technology for Vortex Flow Detection
Innovative Dynamics
Cornell Research Park, 244 Langmuir Labs
Ithaca, NY 14850-1296
Gail A. Hickman (607-257-0534)

Innovative methods for measuring and controlling vortex-dominated flows will be developed to achieve enhanced mission performance of advanced technology fighters. The primary objective of this project is to define and quantify experimentally techniques for measuring surface flow patterns and vortex structures. Phase I will demonstrate an innovative concept based on "smart skins" to measure vortex flow fields on a delta wing using sensor arrays integral with the airfoil skin. The basic concept is to measure pressure and shear forces at the surface with thin-film arrays and construct three-dimensional vortex fields using digital signal processing techniques. Laboratory experiments and wind tunnel flow visualization tests will be conducted to demonstrate embedded solid-state transducers in an open-loop mode of operation. The most promising sensors/actuators will be integrated into a thin boot design for Phase II developmental and Phase III in-flight testing on NASA's F/A-18 high-angle-of-attack (AOA) research vehicle. This work will help researchers verify the accuracy of computational fluid dynamics calculations to predict accurately the aerodynamics and behavior of an aircraft maneuvering at high AOA. Successful development of smart skins could produce advanced control mechanisms that will extend fighter aircraft performance envelopes without the complexity and weight penalties of pneumatic control systems.

Potential Commercial Applications: Fundamental knowledge of the spatial and temporal structure of vortex flows would have important uses in boundary layer management, high-angle-of-attack aerodynamics, separated flows, rotor wake interactions, and vane-type vortex generators. The USAF/NASA AFTI Mission Adaptive Wing program and the Advanced Tactical Fighter would directly benefit from this technology.

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037 LaRC
91-1-03.07-2900 NAS1-19513
A Design Method for the Calculation of Supersonic and Hypersonic Flow Fields
Adroit Systems, Inc.
209 Madison Street
Alexandria, VA 22314
Thomas R.A. Bussing (703-684-2900)

The specific innovation in this project results from a desire to increase speed and reduce computer memory requirements for the computation of internal and external hypersonic flows. The approach is to reduce problems involving three-dimensional, embedded elliptic flow regions that require the full Navier-Stokes (FNS) equations to problems for which only the parabolized Navier-Stokes (PNS) equations, coupled with innovative fluid and chemistry models, are required. The innovation involves building analytical models for various embedded elliptic fluid flows, i.e., transverse fuel injection, parallel fuel injection, base flows, and so on, for which the extent of the embedded elliptic flow is small compared to overall flow field. Current FNS methods require one or two orders of magnitude more CPU time and computer memory as compared to PNS methods. In addition, an evaluation of the optimization techniques that could be coupled with these PNS methods will be performed. These new, efficient codes could be run on super workstations to enhance their availability to the design community. This innovation will lead to a new, highly efficient class of design methods applicable to a wide variety of hypersonic problems.

Potential Commercial Applications: The new design method could be applied in the areas of missile design, supersonic aerodynamics analysis, hypersonic vehicle design, and scramjet development.

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038 ARC
91-1-03.08-7212A NAS2-13443
An Open Framework for Subsystem Information Sharing on the ESAA Family of Vehicles
G&C Systems, Inc.
30250 Rancho Viejo Road, Suite B
San Juan Capistrano, CA 92675
Marle D. Hewett (714-248-7212)

This project investigates the applicability of an open framework for subsystem information sharing on the Earth Sciences Advanced Aircraft (ESAA) family of flight vehicles. The innovation is the development of an architecture for sharing information between the subsystems in the ESAA. This architecture will facilitate the integration of processes into this communicating, cooperating, distributed processing environment. The architecture represents a state-of-the-art application of artificial intelligence (expert systems, telesciences) and "open system" computer networking to a well-suited problem. The architecture will provide the necessary flexibility and adaptability for integrating different systems in a variety of aircraft to support the diverse exploratory and data gathering ESAA missions.

Potential Commercial Applications: This work could support a variety of both manned and unmanned autonomous vehicles, including planet surface and atmospheric explorers (such as the Mars Rover), military reconnaissance vehicles, and others. The software systems include both real-time systems executing in on-board computers and ground-based systems.

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039 LaRC
91-1-03.09-1457 NAS1-19545
Improving Access and Use of Graphical Information in Commercial Air Transport
Search Technology, Inc.
4725 Peachtree Corners Circle Suite 200
Norcross, GA 30092
Paul R. Frey (404-441-1457)

This project addresses an effort to improve the accessibility and use of computer-based graphical information in the cockpits of commercial transport aircraft. This improvement derives from the use of principled approaches in both the presentation design and the ease of access of the graphical information. Two unique and innovative aspects are the application of recent research results on the use of an information "abstraction-aggregation space" to the design of computer-based graphics, and the transfer of recent research and development experience on military fighter aircraft information management to management of graphical information in commercial air transport. The results of this effort hold promise for directing and managing the anticipated expansion of computer-based graphical information in the cockpit.

Potential Commercial Applications: Information management systems have wide commercial application in civil air transport as well as in many other industries. In the near term, the most likely commercial application of this project is the development of electronic library systems (ELS) for new commercial transport aircraft. It may prove useful in ELS retrofits as well.

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040 ARC
91-1-03.10-0655 NAS2-13447
Configurable, Icon-Based Expert System for On-Line Documentation
American Research Corporation of Virginia
P.O. Box 3406
Radford, VA 24143-3406
John A. Neal, III (703-731-0655)

NASA has identified a need for a user-configurable presentation of system functional overviews and detailed system documentation. To address this need, this project proposes the innovative application of computer-based expert systems and high-resolution graphics in a diagrammatic (iconic) environment for the presentation of user-configurable on-line documentation of aircraft and ground test systems. The project's technical objectives include evaluation of documentation presentation methodologies, design of an interactive iconic environment, development of an expert system architecture, integration of high-resolution computer graphics,

and testing and verification of the expert system. This effort will demonstrate a proof-of-concept system for on-line graphical presentation of overview and detailed aircraft and test systems. The results anticipate the development of an expert system architecture and graphical user interface that is flexible enough to be used in a variety of complex system documentation applications. Expected NASA application will initially occur in the design, modification, and testing of aircraft systems; benefits will be realized from an increase in design accuracy, system reliability, and safety, and a decrease in man-hours spent on documentation searches.

Potential Commercial Applications: This intelligent interface will be capable of application to a variety of complex system documentation needs. It can be used to provide more efficient and more accurate access to large volume design, performance, and test documentation databases, such as those found in the aerospace and shipbuilding industries.

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041 ARC
91-1-03.10-3302 NAS2-13442
Validation of Flight-Critical Systems by an Automatic Test-Procedure Generation Tool
Frontier Technology, Inc.
4141 Colonel Glenn Highway, Suite 140
Beavercreek, OH 45431-6553
Ronald L. Braet (513-429-3302)

This project will develop technology to test and verify flight-critical systems during design, implementation, and test phases. Flight-critical systems including integrated flight and propulsion control, integrated flight and fire control, self-repairing flight control, vehicle management, pilot-vehicle interface, and flight vehicle sensors are being integrated through software. Analysis and testing of these systems is a very complicated and time-consuming process. Integrated, computer-aided techniques to allow the controls engineer to more easily evaluate systems is needed. This project will explore methods of going from control system block diagrams to a suite of executable test procedures that can be used in evaluating performance parameters and goals for the specified system. Phase I and Phase II are designed to research, develop, and demonstrate a software tool to aid the user in going from a control block diagram to test procedures that can be used to evaluate the performance of the control system described by the block diagram.

Potential Commercial Applications: The resulting product can be directly applied to current and future flight-critical development programs to ease and expedite the verification testing process. It will have a wide range of government and industrial applications once the test procedure generation tool is refined to a fully functional production level.

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04: Materials and Structures

042 LeRC
91-1-04.01-0018 NAS3-26576
A Parallel Computing Environment for Probabilistic Response Analysis of High-Temperature Composites
Applied Research Associates
6404 Falls of Neuse Road, #200
Raleigh, NC 27615
Robert H. Sues (919-876-0018)

A parallel processing environment consisting of software strategies and optimal hardware configurations for probabilistic simulation of the response of high-temperature composite structures will be developed. Probabilistic composite mechanics (PCM) problems have many inherent levels of both coarse- and fine-grained parallelism. However, the software strategies needed to achieve large-scale parallelism do not exist. Moreover, current parallel processor configurations may not be efficient for all cases. Developing an efficient parallel processing environment for PCM problems will make these computationally intensive methods practical for tailoring high-temperature structural composites. The ability to tailor these composites and meet reliability-based design criteria will contribute to making application of high-temperature composites in aerospace propulsion structures possible. Phase I will identify the multiple levels of parallelism in PCM problems and investigate innovative software strategies that can exploit this parallelism while minimizing parallel processing overhead. Two sample problems will then be executed on two different parallel architectures. The results will be used to formulate recommendations for developing optimal parallel processing environments (software and hardware) for PCM problems.

Potential Commercial Applications: This hardware-software package will be used to reduce the need for costly testing of numerous possible composite design configurations to many different load environments. Commercial application would be in aerospace, automotive, offshore oil, nuclear power, and construction industries.

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043 LeRC
91-1-04.01-6627 NAS3-26572

Concurrent Probabilistic Simulation of High-Temperature-Composite Structural Response

Alpha Star Corporation
1544 Sixth Street, Suite 102
Santa Monica, CA 90401
D. S. Klivans (310-458-6627)

A computational method used to integrate and modify existing baseline specialty codes to perform probabilistic simulation of high-temperature composite structural response will be developed. The method employs an innovative multi-level domain decomposition technique increasing the convergence rates through high-level parallel processing. The nodal response of the composite material will be evaluated by means of a probabilistic, multi-factor, constitutive relationship. This evaluation is performed at each element of the structural model for each constituent of the composite material. The multi-level domain decomposition enables expeditious decoupling of structural and material response initiated by any number of primitive variables while exploiting the capabilities of new multi-processor computer hardware. The result will be a fast, probabilistic, non-linear composite structural analysis tool aiding the design of numerous high-temperature components.

Potential Commercial Applications: This package has immediate application to assist the selection and design of high-temperature composite structures for propulsion and airframe requirements on the National Aerospace Plan (NASP) and subsequently derived vehicles. As a commercial package, the parallel processing capability represents a marketing opportunity for numerous parallel computer hardware vendors, and NASA will benefit from its use, support, and enhanced capability.

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044 LeRC
91-1-04.02-9331 NAS3-26515

Adherent, Oxidation-Resistant Coating for Polymer Matrix Composites

R. D. Webb Company
42 Cedar Street
Wellesley, MA 02181
Richard D. Webb (617-237-9331)

High-temperature polymer matrices under development have glass transition and potential use temperatures above 400°C. However, useful lifetime at elevated temperatures is reduced by oxidation of both matrices and fiber reinforcements of components. The goal of this project is to develop adherent, oxidation resistant coatings to extend high-temperature lifetimes of advanced polymer composites. Polymer matrices will be stabilized by thermal aging under inert gas atmospheres to drive anaerobic thermal decomposition reactions to completion. Thin-film barrier coatings will be applied by ion beam assisted deposition (IBAD) to stabilized test coupons in preparation for oxidation testing. The IBAD process uses high-energy ions to drive coating atoms into the substrate, thereby promoting extremely strong coating-substrate bonds. Extended elevated temperature oxidation testing of both coated and uncoated test coupons will be performed to assess the effectiveness of the oxygen barrier coatings. Post-test specimens will be subjected to optical and scanning electron microscopy to evaluate coating/matrix/fiber degradation.

Potential Commercial Applications: Polymer matrix composites with 400°C use temperatures would be suitable replacements for heavier metallic alloys in both commercial and military aeropropulsion systems.

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045 LeRC
91-1-04.03-7780 NAS3-26507

Advanced Area Detector for Real-Time Radiography of Aeropropulsion Materials

Advanced Research & Applications Corporation
425 Lakeside Drive
Sunnyvale, CA 94086
Christopher R. Mitchell (408-733-7780)

The objective of Phase I is to quantify the effect of x-ray scatter on radiographic image quality, test scatter rejection approaches, and generate a conceptual design of a system that will provide better resolution, contrast sensitivity, and dynamic range than is currently available with commercial real-time radiography systems. Presently, real-time radiography systems do not reject scatter and this has a significant effect on the performance of these systems. X-ray systems with enhanced resolution, contrast sensitivity, and dynamic range are needed for the imaging of advanced aeropropulsion materials that are now being developed. Information gathered from such a system will be useful in developing accurate models to predict material behavior. Incorporation of such a system with a load frame will allow information to be gathered on how these materials behave under mechanical load. The system will also be designed to be compatible with a future upgrade to a volumetric computed tomography (CT) system, providing even greater information on advanced material behavior. NASA will be able to use both the near real-time radiographic and volumetric computed tomography systems to study advanced aeropropulsion material behavior and provide information to guide the modeling of these material systems.

Potential Commercial Applications: The construction of a real-time radiographic system with enhanced resolution, contrast sensitivity, and dynamic range over currently available systems will extend the use of these systems, open up many new applications of x-ray imaging, and lead the way to volumetric computed tomography (CT) systems that will greatly increase the throughput and utility of CT technology.

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046 LeRC
91-1-04.04-8080 NAS3-26568
Process Optimization by Visualization Technology for Composites Manufacturing
Technical Research Associates, Inc.
410 Chipeta Way, Suite 222
Salt Lake City, UT 84108
William R. Hughes (801-582-8080)

Performance of advanced composite materials for use in aeropropulsion depends to an extent on the complex processes required for their fabrication. There is a need to better understand and control such processes through numerical simulation and process optimization techniques. The goal of this project is to develop new visualization technology with capabilities that can be directed toward process optimization for advanced composite manufacturing and improving the understanding of cause and effect relationships among fundamental process parameters. Further significance of the innovation resides in the generic capability as a model to show complex relationships of large numbers of variables, and to add or change any of the variables while observing effects on all the other variables. Phase I objectives include demonstration of this solution relative to the basic manufacturing methodologies of filament winding, RTM, and pultrusion. Anticipated results include demonstration that performance of a composite material can be optimized by balancing one variable against another in the overall process. Understanding of how variables relate to other variables will be gained by analysis of multi-dimensional displays.

Potential Commercial Applications: Space programs will benefit from higher performance materials made possible by process optimization. Process optimization for composites will benefit aircraft, automotive and truck, marine, sports, electrical and construction, and medical applications. Cost savings through improved yields could be quite impressive.

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047 LaRC
91-1-04.05-0236 NAS1-19550
Lightweight, SiC-Ceramic-Foam, Mirror Structures
Ultramet
12173 Montague Street
Pacoima, CA 91331
Brian E. Williams (818-899-0236)

Projected NASA civil and commercial space missions will require power systems capable of greater versatility and higher power levels than those currently available. Advanced solar dynamic (ASD) power systems offer the potential for efficient, lightweight, survivable, relatively compact, long-lived space power systems. The solar concentrator, a key component of the ASD power system, must be lightweight, dependable, and resistant to chemical attack. State-of-the-art mirrors for concentrator panels are too heavy and the surface slope error is too high. In a recently concluded program, the company has developed a mirror fabrication process in which six inch-diameter optical quartz (SiO_2) faceplate mirror surfaces, fabricated by chemical vapor deposition (CVD), were bonded to lightweight ceramic foams fabricated by chemical vapor infiltration (CVI). The resulting mirrors were shown to withstand exposure over the temperature range (from -330 to +250°F) without deviating from a surface slope error of 1.0 mrad over a 72" radius of curvature and a surface roughness of <20.0 A RMS. Phase I will develop a lightweight SiC mirror structure, composed of a CVI ceramic foam structural material to which a CVD SiC mirror surface will be deposited. CVD SiC is highly polishable and has the potential of reducing a real density to <0.20 g/cm^2, a 40 percent reduction from the previous study.

Potential Commercial Applications: The successful completion of this program will result in a significant advance in the technology of ultra-lightweight stiff mirror structures. Potential commercial applications include space optical devices such as telescopes and fast-response laser pointing mirrors, as well as structural and power system components for the Space Station.

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048 LaRC
91-1-04.05-9101 NAS1-19525
Methods for Optimizing Molecular Weight Control of a New Thermoplastic Polyimide
Imitec, Inc.
P.O. Box 1412
Schenectady, NY 12301
Berry Tung (518-374-9101)

A new thermoplastic polyimide designated LARC-I-TPI has been invented at NASA Langley Research Center. It is an amorphous polyimide with a high glass-transition temperature developed for the fabrication of strong, lightweight aircraft structures. The LARC-I-TPI polyimides demonstrate improved melt-flow and adhesive properties. Superior high-temperature properties and the real possibility for substantial raw material cost savings make it an ideal candidate for use in both subsonic and supersonic aircraft. This project addresses two key areas for the development of a commercially available product--case of processing and availability of a required dianhydride compound. It has been shown that ease of processing is related to molecular weight control. Several factors that influence molecular weight distribution, including process conditions, selective endcapping, and purity of monomers, will be investigated. Since the dianhydride required is not commercially available, this project will develop a process for the manufacture of 4,4'-Isophthaloyldiphthalic anhydride and produce quantities sufficient for use in these studies. A special emphasis will be placed on purity to promote molecular weight control. The firm foresees the development of processes that are economically and environmentally sound. The firm's success will establish the basis for future commercial production of LARC-I-TPI.

Potential Commercial Applications: The LARC-I-TPI polyimide products will find application as matrix resins for high-temperature composites, molding resins, adhesives, laminating resins, and film products that can be supplied in several forms, including solution coatings, powders, molded parts, and extruded films.

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049 LaRC
91-1-04.06-5444 NAS1-19541
Producing Foils from Direct-Cast, Titanium Alloy Strip
Ribbon Technology Corporation
Box 30758
Gahanna, OH 43230
Thomas A. Gaspar (614-864-5444)

A promising new technique for direct-casting rapidly solidified titanium alloy strip was developed by the firm with NASA support. The plasma melt overflow process combines transferred plasma-arc, skull melting techniques, and melt overflow rapid solidification technology to direct-cast ribbons and strip. A wide range of alloys can be cast by the process. After casting a near-net-shape strip, there is still sufficient thickness to break up the cast microstructure and develop the mechanical and metallurgical properties by thermal and mechanical processing (TMP) to result in high-quality foils. This project focuses on the development of techniques to produce TiAl and Ti_3Al foils from direct-cast strip using TMP. The techniques that will be investigated include direct casting of strip, heat treatment, wet grinding, and pack rolling.

Potential Commercial Applications: Applications would be in honeycomb panels, metal-matrix composites, turbine exhaust nozzle flaps, and superalloy foils.

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050 LaRC
91-1-04.07-1980 NAS1-19528
An Advanced Carbon-Carbon Composite with Improved Interlaminar and Flexure Properties and Oxidation Resistance
Materials & Electrochemical Research
7960 South Kolb Road
Tucson, AZ 85706
J. C. Withers (602-574-1980)

Carbon-carbon composites have significant potential for use in airframes, hot structural applications on advanced hypersonic vehicles, spacecraft, and engines, but have not reached their potential due to limiting properties of interlaminar and flexure strength and oxidation resistance. An innovative approach that overcomes these difficulties utilizes a SiC conversion coating, without or with whiskers, on the graphite reinforcements; doping of the carbon matrix with a gradation to the surface to inhibit oxidation and match CTE of a coating system that encompasses a bridge coating; and a proven oxidation resistant layer and a moisture resistant glaze. A composite-coating system integrally designed will have substantial increased mechanical and oxidation resistant properties over current systems.

Potential Commercial Applications: A carbon-carbon composite with substantially improved interlaminar and flexure properties, and oxidation resistance will have broad usage in airframes, space structures, engines, brakes, dies, and so on.

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051 MSFC
91-1-04.08-7900 NAS8-39306
Real-Time Monitoring and Analysis of Thermal Spray Processes Using Machine Vision
Automatix, Inc./Control Vision, Inc. - Joint Venture
755 Middlesex Turnpike
Billerica, MA 01821
John Agapakis (508-667-7900)

The objective of this project is to develop innovative vision-sensing and processing techniques that can be used for real-time visual monitoring and analysis of thermal spray processes. Process R&D and real-time control for high-temperature material coating processes are the main applications of the project. The same monitoring and analysis technology can also find use in spray forming applications. The innovative viewing system suppresses the intense light of the flame or plasma in the video image and allows direct observation of the traveling coating particles. The advanced image processing and analysis schemes will allow in-process determination of important quantitative measures such as the pattern and gross velocity of the particle stream, the velocity of individual particles, the powder mass flow rate, the geometry and turbulence of the plasma or flame, and possibly the temperature of particle populations. Phase I will include a brief review of related work, and analysis of application requirements, particularly focusing on NASA needs, an investigation and prototyping of the proposed vision sensing approaches, and investigation and prototyping of vision processing approaches. On the basis of the above, needs for future R&D will be identified and the Phase II effort will be planned.

Potential Commercial Applications: In addition to direct benefits to NASA and the aerospace industry, where thermal coatings are widely used in advanced propulsion system components, the project has immediate applications in jet engine manufacture, overhaul, and repair in which thermal spray coatings are also widely applied.

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052 JSC
91-1-04.09-1980 NAS9-18691
A Unique Silicon-Carbide Reusable Thermal Protection Material
Materials & Electrochemical Research
7960 South Kolb Road
Tucson, AZ 85706
Raouf O. Loutfy (602-574-1980)

A new and unique process, chemical vapor reaction (CVR), to convert graphite structures to low-density SiC structures will be investigated to produce high-temperature thermal protection materials. Available heat shield materials have temperature limitations of about 2500°F and extremely low mechanical properties. In this project net-shape, low-density SiC with excellent strength, excellent thermal shock resistance, high emissivity, high-temperature capability, and low thermal conductivity will be developed. The properties of the SiC will be optimized by investigating the effect of the graphite precursor's density and microstructure and the effect of CVR process operating parameters. The CVR-SiC materials will also be CVD SiC coated to improve ablation resistance. Test specimens will be fabricated and fully characterized, and samples will be delivered to NASA for evaluation.

Potential Commercial Applications: In addition to a structural insulation for use on the Space Shuttle and other re-entry vehicles, a high-temperature structural insulation will have commercial applications as thermal barrier coatings in gas turbine engines, spark ignition and diesel engines, furnace insulation, and so on.

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053 ARC
91-1-04.09-2525 NAS2-13511
Advanced, Thermal-Protection-Composite Matrix for Aerospace Systems
Applied Sciences Laboratory, Inc.
P.O. Box 90333
Industry, CA 91715-0333
Siu-Chun Lee (818-855-2525)

This project investigates the development of a new type of advanced thermal protection material that is fabricated by interdispersing spherical particles into a fiber matrix. The resulting fiber-sphere composite matrix is light weight and has high strength, high thermal resistance, and a selective surface reflectance. This project will develop analytical models for predicting the thermal performance of the composite matrix and establish its feasibility to meet future thermal protection requirements. This project includes the development of models to predict the radiation properties and radiative energy transport through the fiber-sphere composite matrix. The result will be analytical tools to evaluate and optimize the design and thermal performance of this type of thermal protection material. The composite matrix can be applied as thermal insulation by NASA in future aerospace systems and atmospheric re-entry vehicles.

Potential Commercial Applications: The high-thermal-resistant fiber-sphere matrix can be utilized by the aerospace and refractory industries. Specific applications include heat tiles for re-entry vehicles and thermal insulation for high-temperature furnaces. In essence, the advanced thermal protection fiber-sphere composite can be applied wherever thermal insulation is needed.

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054 ARC
91-1-04.09-6881 NAS2-13510
Continuous-Fiber-Reinforced Composites for Heat Shield Applications
Advanced Ceramics Research, Inc.
4541 East Fort Lowell Road, Suite 211
Tucson, AZ 85712
Kevin Stuffle (602-323-6881)

This program will investigate the feasibility of continuous-fiber-reinforced, zirconium-diboride matrix composites for multiple use heat shield materials. Multiple use heat shield materials would greatly benefit several upcoming NASA programs such as the National Aerospace Plane and the Space Exploration Initiative. Currently used heat shield materials, such as silicon carbide coated carbon-carbon composites, do not have sufficient ablation resistance to survive multiple missions. Zirconium diboride-based materials were demonstrated in earlier programs to have the ablation response required to survive multiple missions, but did not have sufficient reliability in larger scale components. Incorporation of continuous fibers into zirconium diboride will improve reliability and allow fabrication of large scale components.

Potential Commercial Applications: Continuous-fiber-reinforced, zirconium-diboride matrix composites have potential commercial applications anywhere high strength and ablation resistance at elevated temperatures are required. Specific applications include turbine engine components, rocket nozzles, and nose caps.

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055 LeRC
91-1-04.11-1555A NAS3-26570
Traction Drives for Reaction-Free and Momentum-Balanced Systems
Nastec, Inc.
1700 Ohio Savings Plaza 1801 East 9th Street
Cleveland, OH 44114
William J. Anderson (216-696-5157)

Conventional drive systems with the usual reaction torques may prove to be unacceptably disturbing for mechanisms to be operated in low-gravity environments. To eliminate dynamic disturbances, it would be desirable to provide drives that have a zero net output torque

and that maintain a balance of angular momentums. This can be accomplished by utilizing drives with dual, counterrotating speed and torque balanced outputs. Both outputs could be used as active drives. Alternatively, one output could provide functional power, and the other could be dissipated parasitically, or used to drive a flywheel for angular momentum balance. Planetary traction drives have several advantages relative to geared units for aerospace mechanism applications. Among these are zero backlash, low torque ripple, compactness, and the ability to operate in extreme environments without liquid or grease lubrication. A novel, dual counter-rotating output, speed-matched roller traction drive that confers the advantages of traction torque transfer while providing a solution to reaction torques will be developed, producing designs for drives with two specific ratios and power levels. Drive kinematics, size, life, and expected performance will be defined.

Potential Commercial Applications: This mechanism can find application in speed and torque balanced drives for scientific instruments, dual drives for underseas devices, and zero torque reaction drives for vehicles.

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056 MSFC
91-1-04.12-2437 NAS8-39317
Ion-Beam-Modified, Atomic-Oxygen-Resistant Lubricious Surfaces
First Omega Group, Inc.
10205 West Exposition Avenue
Lakewood, CO 80226-3912
Ronghua Wei (303-986-2437)

Lubricous wear surfaces will be developed for use on mechanisms exposed to low-Earth orbit environment for extended periods. Such lubricous surfaces are expected to have long wear and excellent resistance to atomic oxygen degradation. The wear surfaces are created by ion-deposited, diamond-like carbon film and/or ion-implanted chromium or chromium plus oxygen. The ion-beam processing and implantation equipment to be used for this work is unique in that it employs large-diameter ion-beams of very high current density. A novel controlled environment tribotester, capable of providing simulated atomic oxygen environment around the wear tested surfaces, will be used for evaluations. Expected Phase I and II results are surface modification process and evaluation techniques sufficiently developed that NASA may confidently specify the process to create lubricous surfaces on mechanical elements for use in long-duration, low-earth orbit applications such as Space Station Freedom.

Potential Commercial Applications: A surface treatment process that makes surfaces long wearing, lubricous, and resistant to oxygen degradation will provide superior performance in critical civilian and government terrestrial applications.

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057 MSFC
91-1-04.12-3200 NAS8-39320
Solid Lubricants for Aeronautics and Space Applications
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Philip Stark (617-890-3200)

This project investigates the use of improved cubic boron nitride (CBN) thin-films as solid lubricants for long-term NASA space missions. The improved films are deposits using the novel technique of laser ablation. The benefit expected is a new solid lubricant film with significantly greater atomic oxygen resistance and longer life than currently available in commercial products. CBN exhibits exceptional durability, hardness second only to diamond, ultrahigh resistance to wear, and relatively low coefficient of friction. Its resistance to attack by atomic oxygen should be better than diamond. In addition, CBN thin-films can be deposited at temperatures significantly lower than diamond films and on a greater variety of substrates. This unique combination of properties makes CBN a prime candidate for use as a solid lubricant in long-term space applications. Phase I will demonstrate the effectiveness of CBN as a solid lubricant for NASA space applications. Commercially available, polycrystalline CBN (pCBN) will be characterized in terms of its tribiological properties in the as-received condition and after being subjected to atomic oxygen exposure. Simultaneously, pCBN thin films will be fabricated by laser ablation and their performance compared to bulk pCBN and commercially available (non-laser ablated) pCBN films.

Potential Commercial Applications: Commercial applications would exist in the areas of aerospace structural components, automotive engine components, machine tools, and fossil fuel recovery, and would include solid lubricant coatings for a variety of mechanisms including gears, bearings, pistons, actuators, and the like.

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058 LeRC
91-1-04.12-7792 NAS3-26508
Phospha-S-Triazines of Improved Hydrolytic and Thermal Oxidative Stability
Technolube Products Company
5814 East 61St Street
Los Angeles, CA 90040
Kay L. Paciorek (213-727-7792)

This project investigates the synthesis, characterization, and evaluation of phospha-s-triazines of improved hydrolytic and thermal oxidative stability as antioxidants and corrosion inhibitors for polyperfluoroalkylether-based fluids capable of operation in the 330°C to 400°C temperature range. Phospha-s-triazines have been shown to be effective degradation inhibitors up to 343°C preventing interaction with metals and alloys. However, they have also been found to be susceptible to hydroly-

sis. Past investigations revealed that the thermal oxidative and hydrolytic stability of phospha-s-triazines is a function of the nature of the ring carbon substituents, in particular the nature of the directly attached chain segment. Currently available data indicate that thermal oxidative and hydrolytic stability of phospha-s-triazines (as well as triazines) decreases in the following order of ring carbon substituents: $R_fOCF(CF_3)$- > $R_f(CF_2)_x$- > $R_fOCF_2CF_2$- (with $x \geq 2$). On the basis of this ranking it would appear that a $R_fOCF(CF_3)_2$- ring carbon substituent should increase stability to above 343°C. Phase I will test this hypothesis.

Potential Commercial Applications: Perfluoropolyalkylether-based fluids, due to their low-temperature properties, low volatility, thermal oxidative stability, and high viscosity index, are practically the only candidates for any high-temperature liquid lubrication, as well as for long-term space applications. An effective degradation and corrosion inhibitor should raise upper temperature limits without sacrificing desirable low-temperature and volatility characteristics.

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059 MSFC
91-1-04.13-1348 NAS8-39323
Thin-Film, Ultrasonic Transducer for Accurate Control of Fastener Clamp Load
Innovation Plus
30 East Swedesford Road
Malvern, PA 19355
Ian E. Kibblewhite (215-889-1348)

A low-cost, piezoelectric thin-film, ultrasonic transducer, formed directly on the head of a fastener, will allow the precise measurement of clamp load in the fastener to be made during assembly with either hand or power tightening tools. Accurate measurement of loads in fasteners previously installed in bolted joints will also be possible with this technology. Phase I will demonstrate the feasibility of forming transducers for generating both longitudinal and transverse ultrasonic waves directly on fasteners. Expected benefits to NASA include the elimination of joint failures, the reduction of weight in bolted joints through designs taking advantage of higher consistent clamp loads, installed fastener-load inspection capability, and the ability to use power tools, such as low torque reaction, electric-impact wrenches mounted on robotic arms, for precision assembly in orbit.

Potential Commercial Applications: Commercial applications include critical fasteners in the aircraft, automotive, construction, chemical, nuclear, and mining industries.

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060 MSFC
91-1-04.14-6750 NAS8-39302
Torch Improvements for Plasma-Arc Welding Applications
Advanced Welding Concepts, Inc.
P.O. Box 2857
Huntsville, AL 35804-2857
Richard E. Reeves (205-539-6750)

Plasma arc welding (PAW) finds extensive use in aerospace applications because of its ability to weld thick metal sections with few passes and high quality. This effort will investigate means to build on past developments by improving the design of the PAW torch, reducing the variability of the process, and allowing it to be used for applications that are presently inaccessible. Four individual enhancements to the PAW torch will be investigated: direct control of pressure in the plasma gas stream; enhanced inert-gas shielding to minimize oxidation; methods of eliminating arc skew; and a reduced torch envelope. The first three items will reduce variability, thereby improving the quality of welds. The last item will allow mechanized PAW to be used in applications with tighter geometric constraints.

Potential Commercial Applications: The improved PAW torch would find a ready market for its better reliability and repeatability in commercial applications in which aluminum is used, such as the automotive and aircraft industries.

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061 MSFC
91-1-04.14-9500 NAS8-39341
Space Welding Power Control Unit
Space Power, Inc.
621 River Oaks Pkwy
San Jose, CA 95134
See-Pok Wong (408-434-9500)

Space welding capability will be needed for maintaining, repairing, or constructing spacecraft in space. The former Soviet Union has already performed welding in space successfully. Furthermore, future spacecraft will have enough power on board for welding. A cost-effective approach to obtain a space-use welding power control unit by adapting a power conditioning unit (PCU) from an arcjet electric propulsion system for spacecraft will be pursued. Arcjet and welding are both gaseous discharge with very similar load characteristics and power source requirements. The firm, a developer for high-power arcjet PCUs, is currently working on an Air Force program to develop a flight-qualified arcjet system. Welding has been performed successfully with an arcjet PCU breadboard without any modification. The efficiency of this breadboard is well above 96 percent; the specific mass is less than 1.5 kg/kw. In Phase II, a flight-prototype space welding control unit will be built and will be ready for full space qualification. This will enable NASA to perform welding in space.

Potential Commercial Applications: Welding in space can be used to repair or construct military spacecraft as well as commercial satellites. The compact, lightweight, and high-efficiency space welding system could also be modified to an attractive portable welding system for hard to reach areas in nuclear reactors or, other field applications.

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062 MSFC
91-1-04.15-3200 NAS8-39319
Graphite-Magnesium, Metal-Matrix-Composites for Space Structural Joints with Built-In Metallic Inserts
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Uday Kashalikar (617-890-3200)

A low-cost MMC fabrication method for net-shape fabrication of space structural joints with built-in metallic inserts will be developed. Two innovations will be demonstrated during Phase I: low-cost, reusable tooling to pressure cast Gr-Mg components to net shape, and "built-in" metallic inserts in the component to produce strong and reliable MMC joints using conventional metal joining. The firm has pressure cast Gr-Al and Gr-Mg components exhibiting a complete preform infiltration and a controlled fiber-matrix interface chemistry. The MMC specimens have shown rule-of-mixtures modulus and a high strength (>100 ksi). The major issues that need to be resolved to encourage widespread utilization of MMCs in space systems are reducing the cost of tooling and processing, and developing joining techniques for MMC parts by virtue of its reusability. Incorporation of metallic inserts will enable assembly of the MMC components using existing techniques such as welding, bolting, brazing, and so on. A complex shaped Gr-Mg joint component with metallic fittings will be selected, fabricated, and evaluated during Phase I. The process will be optimized to demonstrate repeatability in component properties during Phase II.

Potential Commercial Applications: The successful development of low-cost, easily "joinable" Gr-Mg components will open up commercial applications in automotive and aircraft engines, avionics and electronic packages as well as in high-performance sporting equipment. Phase I will identify candidate commercial applications that will be further investigated during Phase II.

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063 JSC
91-1-04.16-0328 NAS9-18686
High-Resolution, Automated Scanning NDE Method for Locating, Identifying, and Measuring Surface Cracks
CNS Technology, Inc.
81 Lincoln Avenue
Piscataway, NJ 08854
Hui Wang (908-699-0328)

The overall objectives of this project are to design and develop a novel, high-brightness, compact, and low-cost microspot x-ray source employing a liquid metal ion source, and to design and develop a high-resolution, automated-scanning NDE method for locating, identifying, and measuring surface cracks in the range of 0.001 mm to 5 mm. The results would dramatically advance the applications of x-ray NDE technology and significantly promote scientific research and technical development in many important areas, such as aerospace industry, materials and semiconductor industries, life sciences, and medicine. One important space application is to locate, identify, and measure cracks, defects, and other micro-structures both on the surface and in depth without introducing any damages to materials. This project can provide very reliable and accurate information useful for predicting the remaining lifetime of materials as well as in-process, non-destructive evaluation and feedback control during the manufacturing of composite materials, fabrics, and metals in space or on ground.

Potential Commercial Applications: This high-resolution, automated scanning NDE method for locating, identifying, and measuring surface cracks will have uses in materials research and processing, semiconductor industries, life sciences, and medicine.

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064 GSFC
91-1-04.16-3230 NAS5-31939
Advanced Method and Chemistry for Brazing Graphite to Molybdenum and Molybdenum Alloy
Advanced Technology, Inc.
2110 Ringwood Avenue
San Jose, CA 95131
James Intrater (408-432-3230)

This project will entail the brazing of graphite to molybdenum and to the molybdenum alloy TZM. Brazed joints will be made by initially metallizing graphite with a tin-based, thick-film process and then melting pure braze filler metals, including silver, between this metallization layer and nickel-plated molybdenum and TZM. This technique will allow for the manufacture of reliable joints with high resistance to chemical attack in various high-temperature service environments.

Potential Commercial Applications: Commercial applications for such a brazed joint would include graphite electrodes for resistance heating, fuel cells, nuclear

waste disposal cavities, and metallurgical melters. In addition, there is also the potential to fabricate graphite-molybdenum laminate structural composites.

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065 LaRC
91-1-04.17-0003 NAS1-19535
Laser-Based Detection of Contamination on Adhesive Bonding Surfaces
Physical Sciences, Inc.
20 New England Business Ctr
Andover, MA 01810
Victor Dicristina (508-689-0003)

The use of lightweight metallic and composite materials in structures that must function under extremes of temperature, pressure, and loading presents new challenges to design engineers. These materials range from common metals to metal-matrix composites as well as carbon- and silica-based composites. In the joining of these multilayer materials and the welding of advanced metals, the cleanliness of the interface can play a large role in the strength of the resulting bond. Through the excitation of fluorescence in the contaminants by UV light and photoelectric detection methods, a non-destructive imaging technique for the detection of contaminants that hinder surface bonding will be developed. Unlike previous applications of this method, a commercially available UV laser coupled to an image-intensified TV camera to obtain rapid real-time images of large structures, regardless of shape, will be applied. In addition to inspection, the system can be employed to remove contaminants via laser ablation and/or vaporization without damage to the underlying material. Phase I will test the sensitivity of the detection method for contaminants of interest on aluminum substrates, demonstrate laser removal of contaminants, and define a prototype system for development in Phase II.

Potential Commercial Applications: Applications would be in inspection and preparation of metals prior to welding or brazing; contamination detection in the manufacture of layered composite structures, adhesive bonding of composites, and surfaces prepared for film deposition; and detection of contaminants on optical surfaces, semiconductor wafers, and magnetic storage media.

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066 LaRC
91-1-04.17-1167 NAS1-19539
Nondestructive Analysis of Graphite-Reinforced Materials
Radiation Monitoring Devices, Inc.
44 Hunt Street
Watertown, MA 02172
Michael R. Squillante (617-926-1167)

The advent of graphite-reinforced composites has led to major advances in aerospace technology. Such composite materials are becoming essential to modern flight technology due to their exceptionally high strength-to-weight ratios when compared to metals and alloys. Many aircraft and rocket components are currently made from these new materials and many new developments require their unique properties. The use of graphite-reinforced materials (GRM) in aerospace applications has resulted in higher quality materials to meet more demanding performance specifications. As a result, there is a requirement for advances in non-destructive inspection equipment to provide accurate, real-time composition analysis of these composites. Since the properties of these composites are strongly dependent on the ratio of graphite filler to binding resin, a reliable non-destructive technique for the determination of the resin to graphite ratio of GRM in both prepreg and cured forms is essential. To ensure that GRM are suitably made, a radiometric non-destructive instrument allowing the accurate determination of resin constant in both prepreg and final composites will be developed. The instrument will be useful not only for quality assurance but also for failure analysis of key components and structures.

Potential Commercial Applications: The graphite composite analyzer will find numerous applications in the manufacturing of composites. It will not only improve component performance but will reduce the manufacturing cost by reducing the number of rejected parts.

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067 LaRC
91-1-04.17-2701 NAS1-19538
New Digital Radiography System for Nondestructive Testing
Quantex Corporation
2 Research Court
Rockville, MD 20850
Peter K. Soltani (301-258-2701)

This project addresses a new technology for the digital radiography employing a patented storage-phosphor material. Planar screens fabricated from this material can acquire radiation images in much the same way as radiographic film, with the key exception that the images are obtained digitally. This innovative technology will be superior to radiographic film, in that it exhibits a linear response over a radiation exposure range of 100,000:1, exhibits potentially greater exposure sensitivity, and can be re-used. Because of these properties, the storage-phosphor imaging screens can be calibrated to allow quantitative analysis of structural changes in engineering materials and components, as well as precise flaw detection and characterization. The objective of this project will be to demonstrate the specific characteristics of the technology in radiographic imaging. These will include quantification of performance characteristics relative to film and current digital radiography systems, such as fluoroscopy and related scintillator-based system. These will lead to the development of a prototype, digital radiography system during

Phase II that can be used by NASA to perform quantitative non-destructive evaluation of structural components.

Potential Commercial Applications: A digital radiography system is expected to be useful in aerospace applications (e.g., inspection of aircraft structures), power generation facilities, inspection of composite and electronic components, and generally in any industry that currently employs radiography as an inspection method.

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068 GSFC
91-1-04.18-4334C NAS5-31885
Low Outgassing Marking Inks
Utility Development Corporation
112 Naylon Avenue
Livingston, NJ 07039
Harry S. Katz (201-994-4334)

Low-outgassing marking inks that can be applied by silk screen, spray, brush, or stamping and possess good chemical and abrasion resistance will be developed. This objective will be achieved by formulating cationic UV-curable epoxies in combination with photoinitiators, flow control agents, reactive monomers and oligomers, fillers, and pigments that will be tested for abrasion resistance, chemical resistance, gloss, flexibility, cure characteristics, and adhesion. Outgassing will be investigated by determination of weight loss versus time under vacuum at various temperatures.

Potential Commercial Applications: The solvent-free inks and coatings will have superior abrasion resistance adhesion to various substrates, low odor, low toxicity, and rapid cure. These products will be especially useful for packaging industries and printers.

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069 LeRC
91-1-04.19-0578C NAS3-26509
Soluble Precursor Route to Conducting Poly(Azobenzene)
Uniax Corporation
5375 Overpass Road
Santa Barbara, CA 93111
Floyd L. Klavetter (805-967-0578)

The known synthesis methods of poly(azoaromatics) are expensive, time-consuming, and tend to result in short molecules containing three or fewer conjugated azo groups. Nevertheless, such materials, in addition to their commercial potential as dyes, would almost certainly be acid dopable to a highly conducting state, by a mechanism analogous to that observed in the conducting polymer polyaniline. The firm will develop a method for synthesizing poly(azobenzene) via an inexpensive soluble precursor route, thereby avoiding the usual difficulty with the insolubility of higher oligomers. In addition, the method is conducive to chemical derivatization and to co-polymerization.

Potential Commercial Applications: The commercial exploitation of conducting polymers to dissipate electrostatic charge and shield electromagnetic interference is imminent. To take advantage of the opportunities this presents, new stable conducting polymers and suitable means of processing them must be developed. To this end, an organic solution-processible poly(azobenzene) would be highly attractive.

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070 LeRC
91-1-04.19-3149 NAS3-26506
Novel Processing Technology for Stable Electronically Conducting Polymers
Lynntech, Inc.
111 East 27Th Street, Suite 204
Bryan, TX 77803
Oliver J. Murphy (409-822-3149)

Electronically conducting polymers are a new class of material, combining the physical and chemical properties of plastics with the electrical conductivity of metals. Possessing lightweight, high flexibility, and electronic conductivities as high as 10^5 ohm^{-1} cm^{-1}, they can be used as massive materials, e.g., in composites. Conducting polymers are mostly synthesized at present by an electrochemical process that is unsuitable for cost-effective synthesis on a large scale, and their insolubility in solvents and non-melting characteristics yield poor processability. A novel photopolymerization process that can give rise to the greater use of these materials will be developed. The objective of this project is to identify optimum conditions for the UV-light-induced photochemical preparation of electronically conducting polymer materials and to characterize their physical, chemical, and electrochemical properties. The expected result is the development of a low-cost, fast-rate photochemical polymerization process that lends itself to the automated manufacture of conducting polymer materials for use as multi-functional materials and as components of various devices, e.g., rechargeable batteries and photovoltaic cells.

Potential Commercial Applications: Commercial applications are associated with the incorporation of conducting polymers into: fibers and fabrics for radiation shielding in electronic equipment and advanced aircraft; electrode materials for energy conversion and storage, e.g., photovoltaics and rechargeable batteries; and biosensors and iontophoretic drug-delivery systems.

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071 JSC
91-1-04.20-9040 NAS9-18693
Amorphous-Diamond, Protective Coatings for Exposed Surfaces in Low-Earth Orbit
Schmidt Instruments, Inc.
2476 Bolsover, Suite 234
Houston, TX 77005
Mark S. Hammond (713-529-9040)

Amorphous diamond films are films of carbon that possess many of the interesting physical properties of diamond, while lacking its periodic atomic arrangement. The attractive features of amorphous diamond include very high hardness, corrosion resistance, optical transparence, high thermal conductivity, a low coefficient of friction, and the ability to produce very homogeneous, pinhole-free films. Adding to the above carbon's low neutron and ionizing radiation dislocation cross-section, amorphous diamond appears to be an excellent candidate as a rugged coating for materials that suffer decomposition in the oxidizing environment of low-earth orbit. A similar material, diamond-like carbon (DLC), is being developed widely as a protective coating for many industrial applications, yet suffers from thermal instabilities and is susceptible to degradation by oxygen attack due to instable bonding to hydrogen impurities in the first case, and the presence of grain boundaries in the second case. Phase I will investigate several deposition technologies to optimize the growth of truly amorphous diamond (eliminating microcrystallites and grain boundaries) containing only well-controlled impurities (to control thermal properties) on substrates of interest t the current space shuttle and space station programs.

Potential Commercial Applications: Commercial applications range from low-tech household utensils to high-tech oil drilling, bits, aerospace material coatings, and solar cell protective coatings.

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072 LaRC
91-1-04.21-0540 NAS1-19542
Adaptive Materials Using Magnetostrictive Actuation
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Ralph C. Fenn (617-661-0540)

A new class of adaptive materials will be developed using magnetostrictive actuation. These will provide a superior alternative to piezoelectric materials now under development. A unique characteristic of magnetostrictive materials is the contactless transfer of power to the material through magnetic fields. This freedom to separate the electrical components physically from the actuator material has the advantages of eliminating both bulky and unreliable embedded power or sensor leads and shorting by conductive laminations. Physical continuity and integrity of the actuator lamination is unnecessary, and there is greater shape flexibility by using magnetic field alterations. Many magnetostrictive materials have the additional benefits of favorable physical properties that are often lacking in piezoelectric materials, such as toughness, ductility, and stable properties. Phase I will identify magnetostrictive materials, and various magnetrostrictive material and field producing geometries will be analyzed. Proof-of-concept samples will be fabricated and tested for properties of importance to adaptive materials. Phase II will characterize, validate, and integrate magnetostrictive adaptive materials into a structure for evaluation of damping, motion, and shape control. Adaptive materials based on magnetostrictive actuation offer improved reliability, maintainability, and flexibility over existing materials.

Potential Commercial Applications: Commercial uses of the adaptive materials include active vehicle suspension, active structural control, vibration and noise isolation, precision industrial position systems, and ultra-precision machining applications.

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073 MSFC
91-1-04.22-5633 NAS8-39314
Optimal Structural Damping Using Super-Elastic, Shape-Memory Alloys
E-Sorb Systems
285 Sobrante Way, Suite E
Sunnyvale, CA 94086
Darel E. Hodgson (415-527-2567)

Several properties displayed by shape-memory alloys include shape-memory based on a temperature-induced phase transformation, superelasticity based on a stress-induced phase transformation, and excellent fatigue and corrosion resistance that can be exploited individually and in combination to provide both passive and active damping and/or stiffness control for all types of structures. For aerospace structures, in particular, the extremely high specific-energy dissipation on bulk and/or mass and volume basic and the relative insensitivity to temperature variations of some shape-memory alloys enable the design of extremely light and effective damping devices. Device types utilizing this approach include linkage, constrained-layer, and modified-joint devices. This project will develop this promising technology for the damping of aerospace structures by providing materials characterization for all relevant alloys including shape memory, pseudoelasticity, fatigue behavior, temperature sensitivity, internal and hysteretic damping, etc. This will characterize all device types including force deflection hysteresis, reliability, cost, etc., and will demonstrate promising device types for frame structures for a small-scale, shake-table facility.

Potential Commercial Applications: A reliable, cost-effective, precisely controllable damping technology would apply to the design of virtually every type of civil, mechanical, and aerospace structure subject to dynamic loads. For civil structures, this technology promises a solution to seismic and wind problems; for aerospace structures, a new design modality for blast, impact, and

cyclic loading; for conventional mechanical devices, a significant reduction in acoustical and structural vibrations.

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074 MSFC
91-1-04.22-7351 NAS8-39312
High-Loss, Graphite-Epoxy Components Made from Co-Cured Viscoelastics with Thermal Control
CSA Engineering, Inc.
560 San Antonio Road, Suite 101
Palo Alto, CA 94306
Eric M. Austin (415-494-7351)

To prolong life and to enhance the performance of spacecraft structures, the effects of structural dynamics must be reduced. Passive damping has been demonstrated as an excellent means for vibration suppression and for noise reduction. A weight-effective method for passive damping is the use of a structural material that possesses a relatively high level of inherent, or "material," damping. The goal of this project is to develop a highly damped composite material that can be used in many aerospace applications requiring vibration suppression. This integral-damped composite will be made by co-curing a high-loss viscoelastic material between layers of graphite fibers during the fabrication process. Phase I will address several technical issues: viscoelastic materials that can undergo the fabrication process without changing their properties, fabrication techniques, thermal control, and analysis techniques. Prototype components will be fabricated and tested to demonstrate the concept. The outcome will be a hybrid material that retains the best features of its components: high stiffness, low weight, and high loss factor. The technology developed under this project may also be applied to piezoelectric devices that also must be thermally controlled and embedded in a material for maximum effectiveness.

Potential Commercial Applications: The introduction of techniques that can raise the inherent damping of composite materials by at least an order of magnitude will have vast commercial and aerospace applications. The resulting co-cured graphite-epoxy material will be less expensive than many advanced materials and could result in a lighter structure when dynamics is a controlling design factor.

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075 JSC
91-1-04.23-3697A NAS9-18712
Lunar Composite Production Utilizing Solar Energy
Glass Strand, Inc.
861 Emerson Street
Upland, CA 91786
C.H. Coggin Jr. (714-981-3697)

This project will promote the development of technology for processing lunar resources. Specifically, it will demonstrate the production of both glass and glass-fiber composites and refined cast basalt items, using solar energy as the primary thermal energy input. The firm will use a 75 kw solar concentrator to melt simulated lunar regolith. The melt will then undergo several multistep processes to first produce controlled, continuous, glass-matrix material needed for creating a glass and glass-fiber composite from lunar resources. Hardware development will include an electrically heated thermal valve for controlling melt flow, a platinum alloy bushing, and instrumented cooling molds that will provide some active thermal control over basalt crystallization. The results will be useful in future efforts to define a lunar production facility.

Potential Commercial Applications: Glass-glass composites could be used extensively in the electrical products market, in which the materials' high insulation value, excellent tracking resistance, and high-temperature operating capability would be especially valuable. High-temperature properties should make them options for structural elements in hypersonic aircraft and jet propulsion systems, whereas its corrosion resistance properties should be marketable in chemical plants, refineries, food processing, and sewage treatment.

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076 JSC
91-1-04.23-8899 NAS9-18685
Novel Design for Lunar-Magma Electrolysis Cell
Carbotek, Inc.
16223 Park Row, Suite 100
Houston, TX 77084
Michael A. Gibson (713-578-8899)

The firm will develop a new configuration for an electrolytic cell to produce oxygen and metal by-products from lunar soil. This design uses ideas adapted from industrial experience in alumina electrolysis, coal gasification, and ferrosilicon alloy production. The design addresses most of the severe operability issues raised by such a cell. These include melt containment, low-melt conductivity, anode-gas blanketing, control of levels and temperature, and the continuous removal of waste heat and molten, corrosive by-products. The new cell design features are coolant passages in the refractory walls to provide a thin, frozen layer protecting removal; platinum screen anodes tilted slightly from the horizontal to promote oxygen bubble removal while still minimizing anode-cathode distances; local heating/cooling at the molten spent magma taphole to regulate outflow rates by local temperature/viscosity control rather than valves; a sliding refractory gate valve for molten ferrosilicon layer level control. Phase I will identify the power/volume needs of the new cell and will complete the design of a benchscale experimental cell for testing in Phase II.

Potential Commercial Applications: Materials and techniques found successful in a magma electrolysis cell may be applied in alumina electrolysis, refractory

manufacture, metals processing, and other processes requiring corrosive, high-temperature conditions.

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05: Teleoperators and Robotics

077 MSFC
91-1-05.01-2407 NAS8-39325
Fast Three-Dimensional Imaging
Intelligent Automation, Inc.
1370 Piccard Drive, Suite 210
Rockville, MD 20850
Leonard S. Haynes (301-990-2407)

Today's robots use cameras to capture images of the objects to be manipulated by the robots, and attempt to use that image data to learn the exact position of parts, identify problems, inspect parts, detect proximity, and perform other tasks. One of the factors that limits the use of machine vision in manufacturing environments is that camera images are two-dimensional, and the objects to be manipulated are three-dimensional. Three-dimensional information is essential in most realistic applications; hence numerous techniques have been tried to generate depth information from two-dimensional camera images. None of these techniques are acceptable for factory application because they are slow, costly, unusable where objects are specular, and\or inaccurate. This project addresses how to implement a "smart camera" that will generate a full-range map of a manufacturing scene in real time with virtually no computation required. The same camera will also continue to function as a normal intensity-based camera and can be switched from intensity to range mode by switching a single binary line. This new type of camera is named the FAST 3-D Imaging Camera (F3DI).

Potential Commercial Applications: F3DI will provide an entirely new capability not possible with any other technology at any cost. There are obvious applications for robotics, in situations in which a robot uses visual information for sensory feedback, and for automatically guided vehicles.

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078 MSFC
91-1-05.01-2577 NAS8-39316
Adaptive Wavelet Image Processing
Fastman, Inc.
1414 Millard Street
Bethlehem, PA 18018
Michael Tucker (215-691-2577)

The firm has recently developed the adaptive wavelet transform (AWT) and has shown that the AWT is very adept at extracting features from complex one-dimensional signals even in the presence of noise. This project will determine the ability of the AWT to extract features from images in the presence of noise and variable lighting conditions. Phase I will assess the feasibility of utilizing the AWT for robust image feature detection by extending the current one-dimensional AWT software code to two dimensions; by demonstrating the ability of the AWT to decompose images into basis elements highly related to the images' features; by determining how to combine currently used pattern classification and neural networks with an adaptive wavelet preprocessor to detect object regions; and by investigating real-time operation of the AWT.

Potential Commercial Applications: This research will lead to advances in real-time spectral analysis for many commercial and NASA applications, including image processing and speech processing monitoring of machine vibration signals. It can also provide high-ratio data compression for telephone answering machines, voice mail systems, cellular phones, fax machines, teleconferencing equipment, and other equipment.

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079 MSFC
91-1-05.02-1377 NAS8-39324
Multiple Sensor Fusion for Object Detection and Position Finding
Integrated Sensors, Inc.
255 Genesee Street
Utica, NY 13501
Jeffrey C. Brandstadt (315-798-1377)

A system that can detect, track, and recognize objects effectively is needed for robots and teleoperators in space. A multiple sensor fusion system can fill the need. The fusion system being developed here will fuse candidate detection reports to provide accurate track and confident target recognition. The fusion tracker is a combination of a multiple input Kalman filter and a probabilistic likelihood-ratio classifier. The filter generates a single track on each target and clutter point, while the classifier accepts inputs from all system components and makes the final target decision. The result is better acquisition, a more accurate stable track, and confident target identification.

Potential Commercial Applications: The system can be installed in a production line to inspect products, sort and detect defects, and recognize product types. It can be applied to commercial security systems and marine navigation applications to detect intruders or navigate in heavy seas.

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080 JPL
91-1-05.02-1896 NAS7-1186
Multi-Beam, Diode-Laser Radar for Non-Visual Sensing
Science & Engineering Services, Inc.
4040 Blackburn Lane, Suite 105
Burtonsville, MD 20866
Hyo Sang Lee (301-989-1896)

This project addresses the development of a new, cost-effective, compact, active range imager for non-visual sensing in conjunction with retrieval and docking in space operations. The imager will have high-resolution (~1 cm) and long-range (60 km) capability. This sensor is based on the pseudo-random, code-modulated, cw laser radar technique whereby a cw near-infrared laser diode transmitter output is modulated by a pseudo-random code. The return signal is received by a small telescope and then processed using cross correlators to determine the range to the target in real time. Angular information about the target is provided from the well-defined transmitter beam direction. By scanning a multi-beam and processing the data in real time, the range and contour of the target are obtained to form a three-dimensional range image in two presentation formats: digital for robotics operation and a three-dimensional visual display for human intervention. The object to be retrieved will be coarsely located at long range, with range resolution and location improving as range decreased. Phase I's approach will be a proof-of-concept experiment, critical system analysis, and conceptual system design. This sensor will afford the advantage of docking and retrieval of space objects not instrumented for Global Positioning Satellite (GPS) receivers or with damaged GPS receivers.

Potential Commercial Applications: The basic module of the sensor can be utilized as a range finder on a terrain vehicle, and in an airborne altimeter. A wide range of commercial applications of the system is anticipated for robotics, air and surface navigation, communications, and automobile collision prevention as well as optical remote sensing of the atmosphere.

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081 MSFC
91-1-05.02-1992A NAS8-39333
Multi-Degree-of-Freedom Robotic-End-Effector Sensors
Orbital Technologies Corporation
402 Gammon Place, Suite 10
Madison, WI 53719
Thomas M. Crabb (608-833-1992)

The goal of this project is to develop single sensors that resolve the components of force into multiple degrees-of-freedom of forces and torques for application to robotic end-effectors. The tactile sensitivity of the proposed sensors, and their ability to detect and measure normal and shear forces and torque, would make possible new and more versatile robotics applications. The direct monitoring of these factors, combined with induced information such as slippage and center of gravity, would considerably expand the capabilities of most teleoperated and automated robotic devices. The sensor can be configured into various shapes to conform to the tips and surfaces of various robotic fingers and end-effectors. This project specifies sensor development primarily for small end-effectors that can be used for materials and sample handling for intra-vehicular experiment operations; extra-vehicular applications and industrial end-effector applications are equally viable.

Potential Commercial Applications: Environmental sensing of most automated/teleoperated systems will find uses in satellite servicing, repair, and assembly operations, in manufacturing ordnance handling, and in operations in harsh chemical or radiation environments.

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082 JSC
91-1-05.02-2803 NAS9-18681
A Compact, Solid-State Range Sensor with Millimeter Depth Resolution
MXR, Inc.
P.O. Box 370
Dexter, MI 48130
Philippe Bado (313-426-2803)

The goal of this project is to demonstrate a high-resolution active ranging system using low-temperature-grown (LTG) GaAs photoconductors as depth sensors. These newly developed, solid-state devices are characterized by an exceptionally broad frequency response (up to 375 GHz at -3 dB) and a high sensitivity (70 percent quantum efficiency). To reduce the noise background, they can be gated on a picosecond time scale. Low-temperature-grown GaAs photoconductors are compact, sturdy, and efficient. Phase I will study the range and the resolution of an active ranging system using LTG GaAs sensors. This solar-blind, active ranging system will be able to operate in environments with highly variable illumination. A correlator embodiment will provide millimeter depth resolution and range extending to several hundred meters.

Potential Commercial Applications: Millimeter-resolution ranging systems based on the firm's LTG GaAs depth sensors can be produced inexpensively in high volume. Single-sensor devices will be used for ranging and collision avoidance. Multi-sensor devices will be able to collect true three-dimensional images of remote objects and will be used in many robotics applications.

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083 JSC
91-1-05.02-5042 NAS9-18704
Tactile Displays for Whole-Arm Manipulators
Begej Corporation
5 Claret Ash Road
Littleton, CO 80127
Stefan Begej (303-973-5042)

The use of tactile sensory data for the control of whole-arm manipulators (WAMs) is hampered by a lack of suitable devices capable of providing tactile feedback to the operator. The objective of Phase I is to address this problem by undertaking the development of an innovative tactile display specifically designed for application to WAM systems. The work scope includes the formulation of design specifications for a WAM forearm display; performance of advanced development upon tactile display technology previously developed at the firm; development of a thin, flexible matrix in which the tactile display elements ("tixels") are to be embedded; fabrication of a 5x12 tactile display array for a lower WAM forearm; fabrication of an advanced display driver; assembly and testing of the display system; preparation of the final report; and delivery of the WAM forearm tactile display prototype to the sponsor for further evaluation. Phase II will deliver a complete tactile display system (upper and lower forearms, chest, and stomach) to NASA in support of ongoing WAM programs.

Potential Commercial Applications: Important markets are foreseen in industries involving remote manipulation of large objects in toxic, pressurized, or thermally extreme environments, e.g., space operations; handling of toxic chemical or biological materials; undersea mining or salvage operations; hot-object handling during manufacturing operations; and operations in extreme cold-weather regions.

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084 MSFC
91-1-05.02-7199 NAS8-39315
Intelligent, Digital, Proximity Sensor for Robotic Applications
EL Associates
6154 Winchester Drive
Seven Hills, OH 44131
Edward L. Laskowski (216-524-7199)

Induction proximity switches are used commonly as presence detectors. Commercially available devices are robust, inexpensive, and immune to noisy electrical environments, while generating negligible free-field radiative power to disrupt other equipment. These devices are generally used only in switching applications. This project extends the capability of present devices by adding capabilities for sensing target range and material composition. Furthermore, by utilizing a digital rather than analog approach to device operation, the useful range is also extended. This enables the device to be smaller for a given range. Incorporating an intelligent processor within the unit allows diagnostics at the sensor, target, and application levels. By designing appropriate targets with different materials, target identification is also possible. Combinations of sensor elements enable three-dimensional measurements, including rotation. These improvements are beneficial to the positioning and control of remote robot arms. The digital proximity sensor is applicable to internal use within the robot or, externally, to sense alignment of robotic operations.

Potential Commercial Applications: The digital proximity sensor can be applied to measure metal thickness and position in strip mills, to robotic position control of automotive assembly equipment, and as a guidance alignment sensor for docking and positioning of unmanned vehicles and robots. Coupled with a mechanical target assembly, it can measure force, torque, and grip of robot actuators.

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085 KSC
91-1-05.02-7828 NAS10-11860
Sensor Technology for Robotic Obstacle Avoidance
Merritt Systems, Inc.
P.O. Box 2103
Merritt Island, FL 32954-2103
Bill Parton (407-452-7828)

Sensors and sensor employment techniques that can be used to provide environmental proximity information to control robotic devices will be evaluated. The major objective of this project is to identify sensor technologies best suited to provide robots working in the vicinity of flight hardware with information about their operating environment. This information could be used to operate a low-level safety system or as input to a motion-planning algorithm to create collision-free paths for an entire manipulator. Various sensor mechanisms potentially including optical, sonic, field, and tactile will be evaluated against samples of materials found in typical NASA launch vehicle and payload processing environments. Each sensor will be evaluated on several criteria, including medium effectiveness, implementation feasibility, and economic practicality. An evaluation testbed will be constructed to compare sensors using materials typically found in a flight hardware processing environment. In addition, prototype sensor cells, based on the innovative utilization of micro-controller technology, will be developed. Research will be conducted to explore techniques suitable for creating a viable sensor-skin by evaluating the interaction of two or more prototype sensor cells. The prototype cells will be constructed and tested so as to demonstrate the feasibility of a multi-cell sensor skin.

Potential Commercial Applications: Applications in the industrial area would be sensor cells that can be developed into sensor skins for robots and autonomous guided vehicles; in the consumer area, sensor cells for consumer autonomous robotic devices; and, in the

academic area, sensor cells for prototype robots in university research labs.

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086 JSC
91-1-05.03-0540 NAS9-18673
Advanced Induction Servomotor
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Richard L. Hockney (617-661-0540)

This project will design, fabricate, and demonstrate an advanced induction servomotor and control system concept having high positioning precision coupled with outstanding electrical noise characteristics. The concept will incorporate a unique multi-disk, axial air-gap induction motor driven by a resonant converter operating at 20 kHz. The resonant converter uses pulse-population-density modulation to both operate the induction motor as an extremely power-dense and efficient, four-quadrant, variable-speed actuator and to actively suppress output shaft torque ripple. The pulse-population-density modulation approach provides inherent suppression of electromagnetic interference (EMI) while minimizing required filtering and shielding. The control system will be sensorless, providing feedback control based on estimated motor state. The project will result in a space-certifiable design having a combination of small size, low EMI, and low harmonic levels not previously possible with brushless servomotors. Phase I will provide a preliminary design and detailed planning for Phase II. Phase II will construct a prototype unit for testing based on the preliminary design developed in Phase I.

Potential Commercial Applications: The project's goal is to reduce the weight of robotic systems by improving the efficiency and reducing the weight of the electrical distribution and drive system. In addition, the development of improved electro-mechanical drives will have application to aircraft, commercial ships, and industrial controls.

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087 GSFC
91-1-05.03-0661 NAS5-31881
Variable-Torque Clutch and Brake for On-Orbit Robotic and Other Mechanisms
Honeybee Robotics
204 Elizabeth Street
New York, NY 10012
Steven Jon Glapa (212-966-0661)

A compact, highly controllable, fail-safe clutch and brake unit for use in on-orbit robotic manipulators and terrestrial mechanisms will be developed. The unit combines the strength and simplicity of the conventional over-running clutch with the controllability of the electromagnetic friction brake, while potentially eliminating wear and repeatability problems associated with the latter. The project objectives are to confirm analysis of the mechanism's detailed force geometry and develop initial control architectures; estimate cost, manufacturability, and performance characteristics; "trade off" against current technology; and build and evaluate a simple breadboard model of the critical geometry. The results of this project will be concrete determination, through analysis and testing, of initial concept feasibility; a quantitative estimate of competitiveness; and an initial design for the first full prototype to be evaluated and evolved in Phase II. This innovation will satisfy a critical need in on-orbit robotics for mechanisms that facilitate safely controlled torque reactance.

Potential Commercial Applications: This innovation has potential terrestrial application in any industry segment employing conventional electromagnetic clutches and brakes.

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088 LaRC
91-1-05.03-2407 NAS1-19526
Magnetostrictive Bi-Directional Linear Actuator
Intelligent Automation, Inc.
1370 Piccard Drive, Suite 210
Rockville, MD 20850
Leonard S. Haynes (301-990-2407)

This project involves the conceptual design of a hydraulic bi-directional linear actuator. A "hydraulic actuator" built using the firm's concept would require no separate hydraulic power source, no hydraulic valves of any kind, would have much higher frequency response and resolution than conventional technology, would be fast, and able to exert large forces. Resolutions of .00002 inches with velocities of 100 inches per second are achievable with bandwidths exceeding 1000 hertz. There is no other linear actuator technology that can come even close to this performance.

Potential Commercial Applications: This system represents an entirely new class of hydraulic actuator that could also be used as a pump. If optimized for resolution, it could be used to meter fluids or gases at high resolution. If built larger and optimized for flow rate, it could be used as an ultra-quiet (no propeller and no moving parts) propulsion system for torpedoes or similar ordnance.

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089 JPL
91-1-05.03-3064 NAS7-1158
Serpentine Manipulator
Redzone Robotics, Inc.
2425 Liberty Avenue
Pittsburgh, PA 15222-4639
Chris C. Fromme (412-765-3064)

Phase I will perform a feasibility test of a multiple-degree-of-freedom, planar serpentine robotic arm. The

serpentine arm will be an innovation over common six-degree-of-freedom robots, which are not capable of performing operations in highly constrained spaces. A fully evolved serpentine manipulator will be an invaluable tool for tasks such as the inspection, check-out, light manipulation, and general processing of shuttle payloads. The planar serpentine arm will have direct application to a subset of payload processing tasks, and will provide a development platform for a NASA R/R&D program to develop a multiple-degree-of-freedom robot capable of moving in three dimensions.

Potential Commercial Applications: The system will be optimized for use in inspection, check-out, light manipulation, and general processing of shuttle payloads, will have general applicability in other NASA task domains, and high potential for use in non-space industrial applications, especially nuclear plant servicing.

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090 GSFC
91-1-05.03-5991 NAS5-31916
Rate-Control Joystick with Vibration Force Feedback
California Cybernetics Corporation
10322 Sherman Grove
Sunland, CA 91040
Helen Greiner (818-353-5991)

Telerobotic experiments have shown the advantage of using force feedback and compliance. In space applications, however, the currently available force-reflecting hand controllers are inadequate for several reasons: lack of reliability, insufficient work volume, and bulky construction. The current space robot control applications use rate-control joysticks exclusively. Phase I will establish the feasibility of using vibrations of a semi-rigid, rate-control joystick to provide force feedback. A complete, flight-qualifiable six-degree-of-freedom force-reflecting, rate-control device will be constructed in Phase II.

Potential Commercial Applications: A force-reflecting, rate-control device has numerous applications in such fields as underwater exploration, oil drilling, hazardous materials handling, or any of the areas in which moving machinery is controlled by joysticks. The use of vibrational force feedback will make the joystick tougher and more practical for use in harsh environments.

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091 JPL
91-1-05.05-4717 NAS7-1172
A Fault-Tolerant, Intelligent, Robotic Control System
Sohar, Inc.
8421 Wilshire Boulevard, Suite 201
Beverly Hills, CA 90211-3204
Kam Sing Tso (310-653-4717)

The goal of this project is to develop the application of a distributed fault-tolerant system architecture for robot control in order to tolerate hardware and software faults, and a knowledge-based diagnosis and recovery system to tolerate faults due to operational errors. The underlying architecture to support this research is the extended distributed recovery block (EDRB). Fault-tolerance provisions already implemented in the architecture include protection against failures in application software, system software, hardware, and networks. The knowledge-based system will use the expert system shell, CLIPS, developed at the NASA Johnson Space Center. Advanced automation techniques such as rule-based and model-based reasoning will be utilized to monitor, diagnose, and recover from unexpected events. The two-level design provides tolerance of two or more faults occurring serially at any level of command, control, sensing, or actuation. The potential benefits of such a fault-tolerant, robotic control system include a minimized potential for damage to humans, the work site, and the robot itself; continuous operation with a minimum of uncommanded motion in the presence of failures; and more reliable autonomous operation, providing increased efficiency in the execution of robotic tasks and decreased demand on human operators for controlling and monitoring the robotic servicing routines.

Potential Commercial Applications: Fault-tolerant techniques building dependable robotic systems can be used in applications that require a high degree of reliability and safety, such as servicing tasks in Space Station Freedom, waste cleanup tasks in nuclear facilities, and patient-tending tasks in medical facilities. The knowledge-based fault diagnostics and recovery system can also be used in industrial robots to cope with various unexpected events occurring during the manufacturing process.

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092 JSC
91-1-05.06-7730 NAS9-18694
Zero-Gravity Simulator in One-Gravity, Air and Vacuum Environments
Barrett Technology, Inc.
545 Concord Avenue
Cambridge, MA 02138
William T. Townsend (617-868-7730)

The goal of this project is to design and build an automated suspension system that closely simulates zero-G in a one-G environment. The suspension system is based on the innovative use of new mechanisms recently invented and patented by the principal investigator. The system will be capable of handling a variety of object sizes and shapes and will be compact and light-weight. Estimates show that for a suspension system handling 3-kg objects, the trajectory error will be only 5 percent. Since the system does not use buoyancy, it is not restricted to a water tank. In fact, the key mechanisms have been designed to allow operation in a vacuum environment. Phase I objectives are to

determine the zero-G performance requirements and compare them to the potential accuracy of the proposed simulator. Once the design and testing specifications for such a system have been determined in Phase I, a turnkey prototype system will be designed and built in Phase II. A series of experiments will then be performed to determine the range of acceptable object sizes and shapes, accuracy, and simplicity of use.

Potential Commercial Applications: This innovation is aimed primarily at commercial and NASA space activities. A zero-G simulator on Earth will expedite program development, verify probability of success, and reduce preparation costs for flight.

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093 LaRC
91-1-05.06-9200 NAS1-19521
Miniature, Fiber-Optic-Coupled Range Scanner
Coleman Research Corporation
5950 Lakehurst Drive
Orlando, FL 32819
Dana Simonson (703-719-9200)

This project will develop a robust, miniature three-dimensional laser radar for measurement of steps, gaps, and contours of the Space Shuttle's thermal protection system (TPS). The approach is a miniature, fiber-optic-coupled, range scanner designed to function as a three-dimensional, coherent, laser-radar topographical measurement system. This will result in a robust miniature three-dimensional laser radar suitable for use with robotic end-effectors. The innovative merger of laser radar technology with a fiber-coupled GaAs integrated optical solid-state scanner provides a realistic solution to the problem of TPS measurements. This measurement system will also provide reflectance data that is independent of background illumination.

Potential Commercial Applications: Commercial applications include robotic measurement and inspection in confined environments.

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094 GSFC
91-1-05.07-0970 NAS5-31917
Robotic Analog of Biological Tissue for Mechanical Transduction
Netrologic, Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
Albert F. Lawrence (619-587-0970)

This project involves two approaches to muscle-like activator systems. It will model and characterize electro-mechano-chemical (EMC) properties of electron conjugated conducting polymers (polypymole PPY; in thin sheet form) and conducting polymer-polyelectrolyte moiety (polyacrylomile PAN, chemically modified; in thin fiber form). It will simulate multi-joint chains driven by redundant muscle-like actuators under quasi-static conditions. Performance indexes derived from a non-equilibrium thermodynamic analysis of EMC-coupled phenomena that are analogous to the degree of coupling and conversion efficacy already defined for mechano-chemical processes and electrokinetic-coupled phenomena will be addressed. These indexes will define the maximum theoretical efficiency of an EMC machine and will indicate general criteria to improve. EMC phenomena will be described by formulating phenomenological (macroscopic) kinetic models of ion motions and redistribution inside the polymer under the action of the electric field and electrochemical reactions at the electrodes. If successful, the system will enable NASA to field robotic systems capable of human-like dexterity.

Potential Commercial Applications: Many commercial applications in private industry as well as NASA can result with robots capable of human-like tactile sensitivity that enables the handling of very fragile materials.

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095 GSFC
91-1-05.07-2075 NAS5-31915
Compliant Artificial Muscle for Telerobotics
Exos, Inc.
8 Blanchard Road
Burlington, MA 01803
Beth Marcus (617-229-2075)

A compliant artificial muscle (CAM) for telerobotic systems that overcome the limitations of conventional actuators will be designed and developed. The firm will use prior work in polymer gel actuators and knowledge of telerobot design issues to answer the questions required to develop a commercially viable actuator system using this technology. The CAM will have strength and speed similar to human muscle. Due to its physical compliance, it will permit telerobotic systems to be developed without the complex transmissions and restrictive shapes required by conventional actuators. Telerobotic systems utilizing the CAM will be strong, light-weight, flexible, and compact. This will make them ideal for space applications in which launch weight and volume must be minimized. The goal of Phase I is to demonstrate the feasibility of the CAM by establishing its material properties and building a prototype comparable to an electric robotic actuator available with today's technology.

Potential Commercial Applications: CAM actuators have enormous potential for a wide variety of commercial applications such as general purpose actuators, biocompatible actuators, valves, solenoids, drug release devices, sensors, laparoscopic and arthroscopic surgical instrument actuators, and tactile display.

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096 LaRC
91-1-06.01-1671 NAS1-19515
MIMD-Embedded, Data-Processor Architecture for Spacecraft Computers
Aeronix, Inc.
1775 West Hibiscus Boulevard, Suite 304
Melbourne, FL 32901
Ronald J. Capasso (407-984-1671)

Phase I will define the development of a parallel processing computer architecture for application to a computational intensive class of problems associated with spacecraft systems. This embedded data processor (EDP) will apply currently available hardware, custom ASIC devices, and a unique control system. The architecture will be based on a partitionable SIMD-MIMD architecture, which can be configured as one or more independent SIMD and/or MIMD processors. The project addresses three problems: present space systems tend to lag in the application of technology; the realization of advanced architectures for space systems is limited by the restrictive packaging requirements; and high-level language support for space systems is minimal. In addition to addressing these problems, the EDP will offer significant increases in performance (1000s of MIPS) over conventional architectures while improving overall system reliability and fault-tolerance. The EDP will support software development in Ada. The basic architecture and component technologies employed will directly support space-based embedded processing systems.

Potential Commercial Applications: This development has potential in applying existing technology to embedded processing problems, in developing a reconfigurable, modular on-board data processing box, and in commercial AI/expert systems

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097 LaRC
91-1-06.01-2006C NAS1-19540
Novel, Multi-Layer, Optical, Mass Storage
Reveo, Inc.
200 Saw Mill River Road
Hawthorne, NY 10532
Sadeg M. Faris (914-741-2006)

Numerous problems in science and engineering require powerful computers with tera-FLOP speeds that demand the concurrent availability of mass storage media with T-Byte capacities and data rates exceeding 1 giga-bit/sec. This project introduces a new read-write optical storage technology that meets the above requirements. It is based on the cholesteric, liquid-crystal (CLC) polymer property of selective reflection at a characteristic wavelength. Each layer in a multi-CLC-layer storage medium has a different characteristic wavelength, making it possible to select randomly any layer for reading or writing. It is projected that a 16 T-Byte erasable mass storage system with a data rate of 1.6 T-bit/sec can be built using this breakthrough technology. In Phase I, a 5-layer storage system will be designed and the feasibility of random layer addressing demonstrated. The Phase I design will be built in Phase II to demonstrate the feasibility of the new technology, with product development and commercialization of the technology to follow in Phase III.

Potential Commercial Applications: Supercomputers with tera-FLOP speeds will greatly benefit numerous applications such as aerodynamics for advanced aircraft designs, chemical modelling, galactic dynamics, and atmospheric science.

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098 ARC
91-1-06.01-2935 NAS2-13528
Multi-Compiler for Aerospace Parallel Processing
Conceptual Software Systems, Inc.
17962 Sun Knoll Drive
Yorba Linda, CA 92686-5114
Ed P. Andert (714-996-2935)

The search for computational advances for aerospace applications requires methods and software for easing the task of developing efficient programs for parallel computers while retaining efficiency of programs transferred between architectural designs. The design and optimization of efficient and reliable parallel software requires a high level of computer assistance. Most current parallelization efforts attempt to automatically extract parallel designs from scalar code. These tools are architecture-specific and achieve only limited speed-up because the in-depth knowledge required for significant speed-up is missing from the scalar design. The multi-compiler approach concentrates on the reverse expansion process--finding efficient mappings from a single-level parallel specification into one or more target parallel architectures. This approach utilizes a unique specification model that captures all of the dimensions of a problem that have the potential to be mapped onto the processor topology of a given architecture. Phase I will develop and evaluate a prototype of the multi-compiler to establish the feasibility of the approach. The prototype will be evaluated for its utility in developing parallel software, the efficiency of generated target mappings, and the feasibility of implementing a full system.

Potential Commercial Applications: The multi-compiler will provide for the efficient use and the improved programmability of high-performance computers for users such as government agencies, universities, and businesses with high-performance and large-scale computing needs.

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099 LaRC
91-1-06.01-3729 NAS1-19522
A Three-Dimensional, Visual-Simulation Workstation for Physical Phenomena
Computer Motion, Inc.
270 Storke Road, Suite 11
Goleta, CA 93117
Yulun Wang (805-685-3729)

Simulating and visualizing physical phenomena has become an indispensable tool for science and engineering. The goal of this two-phase project is to build a flexible, high-performance, low-cost system for simulating and visualizing three-dimensional physics-based problems. This visual simulation workstation (VSW) is based on a novel three-dimensional processor, a network transparent three-dimensional graphical user interface, and a flexible, extensible object-oriented software design. The VSW is not a stand-alone computer, but rather a hardware and software combination that is incorporated into a computer network and accelerates three-dimensional problems for the entire network. The VSW computes with a unique three-dimensional architecture that specifically targets the three-dimensional structure of simulation programs. The three-dimensional processor's C++ compiler will support object-oriented program design for both system level and application software. A three-dimensional graphics system--PIX (i.e., PHIGS Interface to X)--will give the VFW an industry-standard graphical user interface and network transparency. The VSW offers a unique simulation tool that gives tremendous flexibility and performance for all three-dimensional applications.

Potential Commercial Applications: The demand for three-dimensional visualization and simulation is growing rapidly in many fields. A few examples are molecular and materials modeling, structural analysis, and animation. The VSW will offer a unique, object-oriented, high-performance solution to the marketplace, and the cost of a single system can be amortized across an entire computer network.

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100 ARC
91-1-06.01-7442 NAS2-13556
Piranha Parallelism: Distributed Self-Management of Computing Resources in a Network Environment
Scientific Computing Associates, Inc.
One Century Tower, 265 Church St
New Haven, CT 06510-7010
Robert D. Bjornson (203-777-7442)

At the present time, typical large-scale computations may comprise at least three major steps: input preparation, possibly on modest, text-oriented workstations; numerical calculation on a large vector or parallel supercomputer; and output examination, most likely on high-performance graphics workstations. Unfortunately, this entails very unbalanced utilization of computer hardware. All the workstations are largely unused (at least in terms of compute-power), and the parallel supercomputer can be so oversubscribed that users have long waits for available time slots. The goal of this project is to alleviate this situation. It will exploit networks of workstations to provide additional supercomputer power through the development of software to dynamically allocate unused workstation cpu cycles to fill the computational demands of large jobs. This will be achieved in the framework of a simple and powerful scheduling model called piranha parallelism. Users will generate parallel tasks following a fixed format, and the tasks will be released into a network-wide task pool. These tasks are guaranteed to be attacked by as many computational piranhas (aka workstations) as have available idle cycles. Phase I will focus on the design and implementation of a prototype piranha system.

Potential Commercial Applications: Commercial and government users will see greatly enhanced output on important applications and will incur far lower hardware acquisition costs, since it will make more effective use of in-place computers in situations where local area networks of workstations are rapidly becoming the standard computing environment.

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101 ARC
91-1-06.01-7450 NAS2-13540
Autostereoscopic Three-Dimensional Display with Increased Resolution
Dimension Technologies, Inc.
2260 Lake Avenue, Suite 200
Rochester, NY 14612
Jesse B. Eichenlaub (716-442-7450)

This project will validate methods to double the resolution of an autostereoscopic, liquid crystal display (LCD) to meet requirements for accurate analysis of fluid-dynamics data. Until now, high-resolution, three-dimensional image processing has been available only on CRT-based displays requiring special eye glasses. Successfully doubling the resolution of an autostereoscopic LCD will enable development of a compact, high-resolution, three-dimensional workstation display. This will allow viewing flexibility without the need for special eye glasses, while decreasing the amount of workspace required to accommodate the display. Three-dimensionality improves the scientists' ability to interpret data and allows improved accuracy in measurement of size, velocity vector, and density. The resolution of LCDs, which is considerably less than CRTs, presents a technical barrier to their use for visualization of complex data. Phase I will validate the technical feasibility of innovative photonic and time-sequencing techniques that will double resolution of an LCD when in three-dimensional mode.

Potential Commercial Applications: Applications for double the resolution LCD-based autostereoscopic, three-dimensional display include dynamic fluid-flow

analysis, visual study of other natural scientific phenomena, military and commercial avionics, in-vehicle situational displays, guidance of remotely operated vehicles and underwater vessels, airport security, bomb detection, explosives monitoring, industrial inspection, and medical imaging.

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102 LaRC
91-1-06.01-8051 NAS1-19516
A Graphically Based, Front-End Application for Computational-Fluid-Dynamics Algorithms
Aerosoft, Inc.
P.O. Box 11334
Blacksburg, VA 24062-1334
David C. Slack (703-951-8051)

A graphically based, front-end application for computational fluid dynamics (CFD) algorithms will be developed. This will facilitate preparation of input to complex CFD applications, will allow monitoring of the solution process while the CFD application is running, and will assist in postprocessing. Included in the data preparation will be the verification of complex grid systems and the specification of and the error correction for input parameters. The front-end application will make use of the FAST postprocessing libraries as the graphical interface. The total real cost required to perform a numerical aircraft simulation of advanced military fighters, a high-speed civil transport configuration, or the National Aero-Space Plane and its associated components will be reduced. Scientific and commercial applications include an improved environment for the aerodynamic analysis and the design of a variety of aerodynamic vehicles (including engine/airframe integration analysis), inlets, combustors, aeroassist space transfer vehicles, and supersonic transport aircraft.

Potential Commercial Applications: This development may find application in the analysis and the design of transatmospheric vehicles, advanced concept fighters, inlets, combustors, and supersonic aircraft.

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103 GSFC
91-1-06.02-3633 NAS5-31920
A Plug-Compatible Architecture for Integrating Heterogeneous, Distributed, Software Development Tools
Symbiotics, Inc.
725 Concord Avenue
Cambridge, MA 02138
Robert C. Paslay (617-876-3635)

A multitude of useful tools exist for designing, testing, operating, maintaining, and managing large software systems. Unfortunately, tools that support particular system development tasks (e.g., requirements specification and traceability analysis) are typically implemented independently by different vendors with little consideration for the life-cycle process as a whole. Accordingly, these tools are implemented with idiosyncratic data models and with data and control interfaces using different programming languages and running on heterogeneous processors. An innovative architecture for nonintrusively integrating disparate program tools into a unified software engineering and management environment will be designed. Specific technical innovations will be the application of object-oriented technologies to conceal tool-specific interfaces; to map transparently across incompatible data mode; to integrate tools transparently across heterogeneous computing environments; and to obtain plug-compatibility, wherein any tool, once integrated, can interact freely with any other tool connected to the framework as full peers. The resulting architecture will enable NASA to unify disparate software tools in domains such as software development, scientific data analysis, and decision support.

Potential Commercial Applications: The technology can be used to integrate new and previously isolated software applications in domains such as concurrent engineering, software engineering and management, office automation, and automated operations support of complex systems (e.g., communications networks).

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104 GSFC
91-1-06.02-6491 NAS5-31911
Microlaser, Spatial-Light Sources and Reconfigurable Logic Arrays
Photonic Research, Inc.
100 Technology Drive, Suite 265
Broomfield, CO 80021
Jack L. Jewell (303-465-6491)

This project will advance the state-of-the-art of an extremely promising device--the vertical-cavity, microlaser, spatial light source (SLS)--for its applications in optical processing. Use of SLS, rather than spatial light modulators, already greatly simplifies the optical systems, making them smaller, lighter, faster, and more robust. Combining both optical and electronic addressing of the microlaser SLS arrays in optimum configurations will further reduce the size and the weight of the processors. Phase I objectives are to map out the possible configurations, to select the most useful to implement into systems under design and construction by other research groups, to design specific epitaxial structures and fabrication processes, and to outline the Phase II project. Meeting these objectives will show how optical processing systems can be made more efficient and competitive than previously realized. The result will be in ultra-fast processors that have minimum weight and space. Since many space missions gather enormous amounts of data, such an on-board processor could alleviate many of the data-related bottlenecks.

Potential Commercial Applications: These processors will find use as coprocessors to speed up digital elec-

tronic computers in space, aboard aircraft, or at home; as pattern recognizers for robotic vision and DOD reconnaissance; and as decision makers for many applications not yet imagined.

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105 LaRC
91-1-06.03-3370 NAS1-19546
Intelligent Pen-Based Engineering Notebook
Software Productivity Solutions, Inc.
122 North 4th Avenue
Indialantic, FL 32903
Vincent J. Kovarik (407-984-3370)

Systems engineering is a highly complex technical skill. Yet, the process of developing a successful system design is very informal. The engineer often shifts between technical research, mathematical analysis, group coordination, end-user interface, and other activities. Because of this highly fluid work style, the engineering notebook has remained the primary means for the engineer to capture and to retain analyses, decisions, and rationale for projects. Unfortunately, the notebook is an extremely inefficient method for transferring the information captured to the work products. For example, requirements specifications must still be entered into a word processor to obtain a requirements document. This project will investigate the development of an intelligent assistant for the systems engineer within a pen-based computer. This assistant will employ knowledged-based technology to perform tasks such as hypertext link formation between requirements penciled in the notebook and the presentation of those requirements in a document. In the software development domain, this will allow the engineer to develop pencil sketches of a relational database organization, to move that to a specification document and by external interface with an expert system on a workstation, transform the graphical notation into data definition statements.

Potential Commercial Applications: Virtually any domain that involves shifts between modes of operation, informal capture of technical information, mobility can benefit from this technology. Civil engineers, research scientists, software developers, process control designers can apply this technology.

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106 JSC
91-1-06.03-3491 NAS9-18709
A Computer-Aided Software Engineering Tool for Risk Management
Greenwich Systems
24586 Hawthorne Boulevard, Suite 6
Torrance, CA 90505
Earl J. Anthony (310-373-3491)

Risk management is a vital part of software system development. Lack of risk management is the major cause of software project failures. The objective of this project is to formalize, automate, and popularize the use of software risk management techniques. A new and unique computer-aided software engineering (CASE) tool will be explored. The tool fills an existing gap between project management and traditional CASE tools by automating the assessment, control, and communication of software risk. This concept supports the software management team by allowing concurrent risk management of large, complex projects such as the current NASA space station effort. It allows risks associated with high-reliability, time- and safety-critical software components, as well as overall project risk, to be consistently defined, analyzed, and documented. The documentation features will support MIL-STD and commercial software development methodologies. The personal workstation system will be designed for all popular operating systems and hardware configurations. It will integrate and share data with existing project management, CASE, and spreadsheet and database programs. A prototype of the user interface and critical functions, a requirements analysis, and a risk management plan for the effort itself will be included.

Potential Commercial Applications: This product has the potential to evolve directly into a commercial CASE product for software risk management. An additional potential exists in a generalization of the tool for risk management in acquisition, technical management, and strategic business planning.

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107 JSC
91-1-06.04-1400 NAS9-18706
A Software Engineering Approach Towards Validation of Knowledge-Based Systems
Vigyan, Inc.
30 Research Drive
Hampton, VA 23666-1325
Mala Mehrotra (804-865-1400)

Currently, most expert-system shells do not address software engineering issues for developing, maintaining, and verifying expert systems. As a result, large expert systems tend to be incomprehensible, difficult to debug or to modify, and almost impossible to verify or to validate. Partitioning rule-based systems into rule groups that reflect the underlying subdomains of the problem should enhance the comprehensibility, maintainability, and reliability of expert-system software. The firm will automatically structure a given rule base so that verification-aid tools can test the behavior of each of these subunits individually, as well as in relationship to each other. Preliminary studies of rule-based structuring have provided insight into the various parameters that affect the grouping process and have shown the feasibility of this approach. More analysis will need to be done to understand the interplay of distance metrics, clustering strategies, various objective functions to be optimized for grouping, and evaluation criteria used to judge the quality of the resultant groups. A significant secondary benefit of this approach will be the formula-

tion of software engineering guidelines to aid the grouping process. Such an environment would help in the verification and validation of knowledge-based systems, allowing them to be used in commercial and critical applications with more confidence.

Potential Commercial Applications: Currently, expert systems cannot be used in critical applications since they are not amenable to existing verification and validation techniques. An integrated environment for expert system verification and validation can overcome this barrier thus opening up a wide range of important applications.

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108 ARC
91-1-06.04-6882 NAS2-13505
Knowledge-Based Astronomical Observatory
Autoscope Corporation
P.O. Box 2560
Mesa, AZ 85214-2560
Russell M. Genet (602-497-6882)

The firm will develop a remote, unattended, knowledge-based observatory operated by a microcomputer. Dependent on observational goals and conditions and the state of the equipment, this system will dynamically and automatically plan and schedule observations, monitor its status and, should a failure occur, determine which module should be replaced. This innovation is a translation of the knowledge of expert astronomers, engineers, and managers into a set of heuristic rules that provides task planning and reasoning in a complex and dynamic environment. Phase I will establish the basic technical feasibility and merit of unattended, knowledge-based astronomical observatories. Two key results will be a simulation of all the major aspects of the system and its decision processes, and a preliminary design of a prototype observatory to be constructed and used during Phase II to demonstrate the practicability of an unattended observatory.

Potential Commercial Applications: The advantages of knowledge-based observatories will be so overwhelming in the area of economy of operation, direct and convenient user operation, and self-diagnosis that dozens of knowledge-based observatories will be sold.

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109 JSC
91-1-06.04-8802 NAS9-18669
Computing Environments for Graphical Belief Models
Statistical Sciences, Inc.
1700 Westlake Avenue North, Suite 500
Seattle, WA 98109
Russell Almond (206-283-8802)

Graphical models--mathematical models using graphs to represent the relationship between variables--can solve problems in fields as diverse as reliability, decision theory, medical diagnosis, and genetics; many classical statistical models can be expressed as graphical modes. Recent artificial intelligence research has concentrated on graphical models; however, currently most graphical model manipulation programs are experimental prototypes. For graphical models to make inroads into the practical design of knowledge-based systems, these must be supported by display and by elicitation tools that make them accessible to a broader class of users. This project will take an existing software prototype, the BELIEF package, and embed it in an extensible graphical display and elicitation tool kit--the GRAPHICAL-BELIEF package. The finished product will provide important functionality, namely, dynamic graphical interaction and display, comprehensive elicitation tools, and graphical explanation facilities. This will make graphical modelling technology available to a broad class of users.

Potential Commercial Applications: As graphical modeling technology matures, more scientists and engineers will want to develop specific applications. The provided tool kits will enable them to rapidly design custom graphical models for a wide range of applications.

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110 JSC
91-1-06.05-8181 NAS9-18711
A Distributed-Information-System Architecture for Planning and Scheduling Tools
I-Kinetics, Inc.
19 Bishop Allen Drive
Cambridge, MA 02139
Bruce H. Cottman (617-661-8181)

Planning and scheduling (P&S) tools require integration with separate data base management system (DBMS) facilities to manage and to share large amounts of scheduling data and knowledge. P&S tools use particularly rich data models for the representation of arbitrarily complex interrelationships and constraints. Conventional DBMS technologies, such as relational and flat file, cannot adequately support P&S data models. Object-oriented DBMSs may be more suitable due to their richer data semantics. The project will focus on the issues and problems of integrating an existing P&S tool, COMPASS, with both relational and object-oriented DBMSs. An architecture will be designed for the management of large amounts of data for distributed P&S information systems. The project approach uses an object-oriented data model that is uniform across heterogeneous development languages, ADA and C; allows existing P&S tools to be maintained and enhanced independently; and extends useful lifetime of existing P&S tools by enabling low-cost integration to new types of information management and processing.

Potential Commercial Applications: A development framework for integration of planning and scheduling

tools with data management systems could be applied in operations support, command and control, and computer-integrated engineering systems. This framework is ideal for the integration of image-processing and knowledge-based systems with existing systems.

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111 JSC
91-1-06.05-8500A NAS9-18696
Realistic Virtual Environment Workstation
KMS
P.O. Box 1567
Ann Arbor, MI 48106-1567
Frederick S. Schebor (313-769-8500)

Recently developed virtual-world, heads-on displays have significantly increased the potential of using computer-generated graphical environments for training and operational scenarios. To enter a virtual-world environment, an operator wears a head-mounted, stereo video display that provides a view of the objects and backgrounds of the virtual-world environment as generated by a color graphics workstation. Head motion is monitored and is used to control the operator's view within the environment. Unfortunately, current virtual-world environments are far from realistic, providing only rudimentary graphical representations of objects. This project plans to dramatically increase the fidelity, usability, and cost-performance of virtual world simulations by designing a real-world scanning system, REALVIEW, that will optimize the "feel" of a virtual world by importing real objects and backgrounds into virtual world environments. Specifically, the firm will design object grabber, background grabber, and world editor/-viewer subsystems that will allow existing objects and scenes to be captured, stored, modified, and rendered in a virtual world. With these tools, an operator will be able to easily create or modify virtual world simulations by manipulating the objects and backgrounds acquired by REALVIEW.

Potential Commercial Applications: The fidelity, usability, and cost-performance of virtual-world simulation make it suitable for substantial commercial applications in such areas as teleoperated and telerobotic systems that depend on realistic simulations.

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112 JSC
91-1-06.05-8522 NAS9-18670
Fuzzy Logic Control for Improving Performance of Thermal Control Systems
Togai Infralogic, Inc.
5 Vanderbilt
Irvine, CA 92718
Jack P. Aldridge (714-975-8522)

Advanced space programs will require automated control of thermal control systems (TCS), both in space and on planetary surfaces, with minimum use of electric power. Further, details of the thermal control processes are likely to be uncertain or even changing over time. Phase I will define and demonstrate the feasibility of an adaptive fuzzy logic-based controller for TCS. The definition will include enumeration of the time-varying factors causing energy use, specification of sensors and controls for these factors, fuzzy logic or related control techniques for driving the controls, and adaptive techniques. An experiment to test the concepts in controlling the thermal (heating, ventilation, and air conditioning) system for a NASA building as a means of evaluating the design methodology and testing achievable power savings prior to applications to spacecraft and lunar or planetary bases will also be defined.

Potential Commercial Applications: Adaptive fuzzy-logic thermal-system controllers could be used to reduce energy requirements in existing or new commercial buildings. The adaptive feature would overcome objections to previous computer controls due to high programming costs. If the cost could be reduced sufficiently, there could be applications for home systems.

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113 JPL
91-1-06.06-5805 NAS7-1168
Operations Planning with Neural Networks
Nienhaus & Associates
1899 N. Fortville Pike
Greenfield, IN 46140
Thomas G. Nienhaus, Jr. (317-462-5805)

Advancements in operations planning algorithms are sought for use in simulations with the time-warp operating system executing on parallel computers. The objective of this project is to determine the feasibility of operations planning with neural networks as the decision making mechanism. This project will consist of construction of a network model, model initialization, and testing. Experiments involving bidirectional associative memories as the neural network will be tested in both sequential and parallel discrete event simulation (PDES) environments. Results of accurate decision making and increased simulation speed could lead to future development of a PDES production version as a planning tool.

Potential Commercial Applications: Advancements in operations planning can be extended commercially to planning for transportation industries, logistics, production factories, and construction.

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114 GSFC
91-1-06.07-3474 NAS5-31938
A CASE Tool for Intelligent Diagnosis of Space Flight System Faults
Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, MA 02138
Alper K. Caglayan (617-491-3474)

Since computing systems are crucial components of space flight systems, the detection and the isolation of flight software and hardware faults are critical in space-flight data systems. Although modest progress has been made in improving hardware and software reliability, there is currently a need for intelligent, fault-diagnosis in space-flight data systems to allow for increased reliability, availability, and maintainability. What is needed is a computer-aided software engineering (CASE) tool for intelligent fault-diagnosis that incorporates the practical techniques from software fault-tolerance in a knowledge-based expert system framework. The goal of this project is to develop a CASE tool for intelligent fault-diagnosis using an in-house expert system shell. The approach will allow the incorporation of software fault-tolerance techniques into a knowledge-based expert system and demonstrate the feasibility of developing a CASE tool for building an intelligent fault-diagnosis system in space-flight data applications.

Potential Commercial Applications: Commercial application would be a CASE tool assisting the implementation of intelligent fault-diagnosis systems targeted to aerospace, electrical, mechanical, and chemical engineering markets by federal contractors, government, and university research laboratories.

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115 ARC
91-1-06.08-4100 NAS2-13529
Bacteriorhodospin, Spatial Light Modulators for Optical Processing
Bend Research
64550 Research Road
Bend, OR 97701-8599
Dwayne T. Friesen (503-382-4100)

This project addresses the need for better spatial light modulators (SLMs) for use in robotic vision, autonomous lander guidance, and spectral data analysis. An improved SLM based on bacteriorhodopsin (BR), an organic material of biological origin with unusual photochromic properties, will be developed. This will be optically addressable and will offer the potential for high-resolution, high-speed updatability, and high contrast. To demonstrate the potential of these BR-SLMs, it will be necessary to fabricate high-optical-quality films of BR. Phase I will be focused on making and optically testing films of BR. Phase II will demonstrate a prototype BR-SLM that has high resolution, high-speed updatability, high contrast and the capability of these devices in an optical-processor application.

Potential Commercial Applications: High-quality BR-SLMs will be broadly useful in constructing optical computing devices that are programmable in real time. Such devices could be used for pattern recognition, synthetic aperture radar, and optical processors and also to implement artificial neural networks. Holographic elements based on BR could be used for reconfigurable optical interconnects, associative holographic memory, manufacturing-processing monitoring, and dynamic-phase conjugate filters.

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116 JSC
91-1-06.08-6116 NAS9-18697
Liquid-Crystal, Fabry-Perot, Optical Modulator
Boulder Nonlinear Systems
2000 5th Street, Unit B
Boulder, CO 80302
Gary Sharp (303-670-6116)

Optical computing techniques capitalize on the inherent speed and parallelism of the two-dimensional processing of a data encoded wavefront. This requires the capability to spatially modulate the light signal. The light can be either amplitude or phase modulated. Current spatial light modulators are usually a two-dimensional array of shutters that provides a binary phase or intensity pattern. Analog or gray scale techniques are being investigated by various researchers, but single-chip devices offering analog phase or amplitude modulation are not currently available. The project is the first step toward achieving continuous amplitude and phase optical processing, while providing superior high-speed and high-contrast modulation for phase-only processing. The proposed spatial light modulator, compared to existing technology, offers next-generation performance, as well as full analog capability. Phase I will demonstrate the feasibility of the analog phase modulator and will investigate integrating the technology with VLSI chips.

Potential Commercial Applications: Initial analysis of the modulator indicates that this approach offers considerable advantages over existing commercial and prototype devices of its kind. The device will also be inexpensive, so that it will have application in various optical processing systems such as robotic vision and particle image-velocimetry.

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117 ARC
91-1-06.08-8933 NAS2-13530
Universal Spatial Light Modulator
Displaytech, Inc.
2200 Central Avenue
Boulder, CO 80301
Mark A. Handschy (303-449-8933)

The proposed work aims to develop "smart" spatial light modulators (SLMs) that integrate photodetectors, light modulators, and electronic intra- and intercell

processing. These SLMs exploit a hybrid optoelectronic technology that places ferroelectric liquid crystal (FLC) light modulators directly atop silicon VLSI circuitry. A small, prototype FLC-VLSI SLM will be designed and fabricated implementing an innovative "universal" function: it would be addressed either electrically or optically, and it would provide programmable image thresholding, subtraction, memory, and inversion. The Phase I prototype SLM should have an array size of 16 x 16 or greater and a frame update rate greater than 1 kHz. This prototype will include pixel circuit design and simulation, VLSI layout, silicon integrated circuit (IC) fabrication, fabrication of FLC modulators atop the IC, and characterization of the resulting SLM. Phase II should result in arrays sizes of 256 x 256 or greater with contrast better than 200:1 and frame rates in excess of 10 kHz. The resulting SLMs will be no larger than a packaged integrated circuit like a microprocessor and will require no specialized driver circuitry beyond a standard logic-level interface.

Potential Commercial Applications: The SLMs should find use in myriad optical processing applications such as correlators and morphological processors. Foreseen commercial applications include use as input devices in optical digital memory systems and as miniature displays suitable for projection or head-mounted virtual reality environments.

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118 MSFC
91-1-06.09-7780 NAS8-39301
Extraction of Design Information from Three Dimensional, Computerized Tomography Data
Advanced Research & Applications Corporation
425 Lakeside Drive
Sunnyvale, CA 94086
Nicolas J. Dusaussoy (408-733-7780)

An innovative approach for generating computer-automated design (CAD) and computer-automated manufacturing (CAM) models from volumetric computerized tomography (CT) data will be developed. This innovation relies on novel image processing algorithms for meshing surfaces and on advanced CT techniques for extracting subpixel surface information. This project addresses important deficiencies currently precluding the automation of stress analysis, model replication, and failure analysis of flawed parts from CT data. Such methods that have been shown to be applicable to advanced composites rely on coupling an accurate three-dimensional geometric description of the part inspected (CAD/CAM) and the associated material information extracted from the CT data into an appropriate finite element model (FEM). The project will enable the execution of both of these critical functions in an adaptive fashion.

Potential Commercial Applications: The availability of an accurate, adaptive data link between the unique quantitative nature of volumetric CT data bases and CAD/CAM and FEM modeling capabilities should have a significant impact on the fields of industrial stress analysis and design, reverse engineering and model replication, and failure analysis. A commercial software package would allow users to take better advantage of the installed and growing base of industrial CT systems.

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07: Information Systems and Data Handling

119 LaRC
91-1-07.01-1696 NAS1-19548
On-Chip Feature Extractor for Imaging Sensors
Tanner Research, Inc.
444 North Altadena Drive
Pasadena, CA 91107
John Tanner (818-795-1696)

This project will investigate, develop, and fabricate an image feature extractor based on a custom integrated circuit. The chip will contain a 64 x 64 array of photoelements and a closely coupled set of analog, neural computational elements to extract features and transmit the feature data offchip. The chip will perform the computationally intensive early stage of neural processing at a rate of 200 million connections-per-second. The closely coupled sensor-extractor architecture and analog circuits match well the low-precision, but massive, computation rate required by the first stages of neural processing in a vision-based robotic system. This approach will utilize standard, readily available CMOS bulk integrated-circuit technology so that products arising from this R&D can be fabricated reliably and economically by a number of vendors. The development of the Phase II image sensors, with integrated neural processors, would lead to an inexpensive product with wide applicability in commercial, academic, and military markets. An integrated sensor-feature extractor chip simplifies neural-network image processing systems in the laboratory and in production. The reduced sized, weight, chip count and power required and also the increased reliability are especially critical to high-performance, artificial vision systems for space applications.

Potential Commercial Applications: This technology will advance the current understanding of analog photosensor arrays and their integration with neural processing circuits implemented with established digital CMOS technology. This may make feasible inexpensive, high-performance neural-networks for industrial artificial vision applications.

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120 GSFC
91-1-07.02-1400 NAS5-31919

Adaptive Ray-Tracing of Time-Dependent Flows on Massively Parallel Computers

Vigyan, Inc.
30 Research Drive
Hampton, VA 23666-1325
P. Sundaram (804-865-1400)

A robust and adaptive ray-tracing algorithm for visualizing the volumetric data obtained from time-varying numerical or experimental simulation will be developed. The ray tracer will be adapted based on a neighborhood model of a suitable function for color and opacity determination. The algorithm is attractive for a massively parallel computer. The method is voxel-based and suitable for arbitrarily shaped lattices. In this method the rendering pipeline is divided into two independent shading and classificate segments in order to eliminate the inaccuracies in opacities that adversely influence the color, and vice versa. The voxel value of color and opacity are approximated in a trilinear fashion to obtain these values inside the lattice along the ray's path. Phong shading and empirical illumination models are also incorporated into the method. The adaptive ray tracer will be implemented on the SIMD-architecture MarPar's MP-1 computer. An unsteady Navier-Stokes solver will be used to yield the temporal change of the data to test the present adaptive visualization algorithm. The actual task of integrating the time-accurate numerical computation and the visualization on the MPC will be attempted during Phase I and implemented in Phase II.

Potential Commercial Applications: Commercial applications would be a very powerful software that is applicable for state-of-the-art parallel computers and vital for research involving time-dependent simulation.

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121 GSFC
91-1-07.02-8100 NAS5-31934

Integration of a SIMD Database Accelerator into Commercial, Relational-Database Management Systems

Data Parallel Systems, Inc.
4617 East Morningside Drive
Bloomington, IN 47408
Sidney W. Kitchel (812-334-8100)

The massive degree of parallelism inherent in SIMD computer systems has been exploited to produce high-performance and cost-effective solutions for many problems in the scientific and engineering communities. An SIMD system that can be used to accelerate important database queries will be developed. Initial results demonstrate that a performance improvement of 20 to 50 times over currently available technology and a cost/performance advantage of 100 times is attainable. The specific database queries that are accelerated are JOINs, Range SELECTs, and SCALAR Aggregates. These three classes of queries combine to underpin the decision support functions of large database installations (as opposed to the transaction processing functions). In addition to providing the potential for increased performance for existing database installations, the nested relational model, which the accelerator supports, can provide the basis for building database systems on complex structured objects such as image and object-oriented databases. The goal of this project is to integrate the accelerator technology developed into commercial relational database products.

Potential Commercial Applications: This project is applicable to satellite and telescope generated images, as well as commercially generated data such as supermarket scanner data that produce huge volumes of raw data.

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122 SSC
91-1-07.03-1813 NAS13-481

Auto-Vectorization of Areal- and Linear-Raster Image Features

Delta Data Systems, Inc.
131 Third Street
Picayune, MS 39466
Andrew A. Rost (601-799-1813)

Remotely sensed images contain areal and linear features that may complement, but are generally not available to, geographic information systems (GIS). Auto-vectorization transforms the tesselated data structure of raster images into the topological data structure of vector-based GISs. This technology can be applied to any raster image including scanned maps. Auto-vectorization combined with auto-attribution and expert system technology will produce an autonomous system for the conversion of maps and remotely sensed images to "GIS-ready" objects. The primary innovations of this project include the integration of remotely sensed data with mainstream GIS packages, the reduction of cost, time, and labor associated with GIS development, and the automatic extraction of linear earth features from remotely sensed images.

Potential Commercial Applications: Applications would exist in expert systems to populate GIS data bases; mapping systems based on computer visualization and/or analysis (i.e., coastline for fault mapping); and resource studies such as tree crop inventory and oil-bearing rock porosity.

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123 SSC
91-1-07.03-8802 NAS13-483
Wavelet-Based Compression and Visualization of Time Series of Images
Statistical Sciences, Inc.
1700 Westlake Avenue North, Suite 500
Seattle, WA 98109
Andrew G. Bruce (206-283-8802)

Wavelets provide a powerful tool for signal and image analysis. Wavelets have a strong mathematical basis and can be used to implement multiresolution image analysis and compression for on graphics workstations. The goal of this project is to develop an "image browser" for visual analysis of images and time series of images based on an x-window system. This tool will give users the ability to carry out both quick visual inspection of many images at coarse resolution and detailed visual data analysis of selected images at high resolution. The firm will also develop methods for image compression using the wavelets approach.

Potential Commercial Applications: The wavelet-based methods will provide graphics workstation software tools to carry out both visual analysis and data compression for images, time series of images, and three-dimensional time series.

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124 SSC
91-1-07.03-9467 NAS13-478
A Geographic, Object-Oriented Database for Geographic Information Systems
Hilton Systems, Inc.
2829 Lakeland Drive, Suite 1302
Jackson, MS 39208
Sidney G. Williams (205-535-9460)

Phase I will identify the capabilities needed to develop a viable system utilizing an object-oriented database (OODB) to support the development of a central repository for defining, classifying, and organizing terrain features. This capability will provide geographic information system (GIS) users with a common set of terrain features and characterizations with which to build their applications. The project will identify key objects and will determine how they characterize and manipulate, how and what information should flow between objects, and how the objects should be abstracted into classes. The effort will produce a prototype that integrates the resulting geographical object-oriented database with a GIS. The prototype will build on new object-oriented data structures and permit evaluation of the feasibility of the geographical object-oriented database concept and its suitability for the problem domain. The prototype will also serve as a major tool in the establishment of system-functional and computer-software-module integration requirements.

Potential Commercial Applications: This project should provide GIS users with a common set of terrain features and characterizations with which to build their applications.

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125 LaRC
91-1-07.04-0200 NAS1-19531
A Highly Concurrent Multiwavelength Fiber-Optic Network
Optivision, Inc.
4009 Miranda Avenue
Palo Alto, CA 94304
Behzad Moslehi (415-855-0200)

A novel, cost-effective, multiwavelength, distributed data system which is capable of providing increased performance and enhanced services, will be developed. This will be done by combining many independent wideband optical information carriers onto a single fiber. This concept is based on combining the best attributes of both wavelength-division multiplexing (WDM) and a fiber distributed data interface (FDDI) into a unique network referred to as highly parallel, wavelength distributed data interface (HPWDDI). WDM provides features such as high concurrency, wavelength bridging and routing, switching, and on-line network health monitoring. FDDI provides commercially available subsystems. The HPWDDI's performance can be upgraded as the requirements grow without making complex changes. This design is one step beyond FDDI compatibility for future standards. An HPWDDI network interface node will be designed and evaluated to demonstrate the concept's feasibility and its applicability to NASA's future advanced onboard distributed data systems needed for highly automated missions.

Potential Commercial Applications: The HPWDDI network has the potential to introduce the next generation of highly parallel terabit networks for applications such as HDTV, computers, communications, telepublishing, scientific visualization, and medicine.

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126 GSFC
91-1-07.04-2276A NAS5-31937
Network Programming Language
Apeiron
P.O. Box 1000, Mail Station 220
McKinney, TX 75070
Kurt K. Christensen (214-423-2276)

This innovation consists of a programming environment in which execution takes place throughout a (perhaps heterogeneous) network of computing devices. From the programmer's point of view, the language appears as an iconic object flow language (such as Prograph) with a few extensions for attaching salience to selected processes. No knowledge of the network architecture or protocol is required of the programmer. From an execution point of view, the language appears to be a threaded set of remote procedure calls, which

may result in execution by any device with the appropriate capability (such as Amoeba). From an operating system point of view, the language appears to reside on a network operating system with an integral database (code store) supporting the remote procedure calls.

Potential Commercial Applications: A successful implementation of this capability could be useful anywhere large numbers of idle computing resources are connected by a communications network. This includes most of the medium to large companies in America. This is particularly interesting when the alternative to this kind of processing is the purchase of a supercomputer or renting time on one.

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127 GSFC
91-1-07.05-5445 NAS5-31943
A Distributed Cataloging System for Heterogeneous Data and Software Centers
Grafikon, Limited
11329 Classical Lane
Silver Spring, MD 20901
Ravindra R. Kulkarni (301-593-5445)

NASA missions have created a multitude of separate data and software centers and a large number of data types and structures. The goal of this project is to develop a product--the distributed catalog system (DCS)--that will help "libraries" catalog holdings over consortiums of data and software centers. DCS will be integrated with NASA's DAVID and AutoLib library systems and thereby provide a unified interface for accessing heterogenous distributed data. The design for DCS will incorporate automatic catalog updates and will access an interactive environment consisting of a consortium of data and software centers interconnected by a wide area network such as NASA Science Internet and NSF Internet. The DCS will allow searching and cataloging of holdings across the consortium of data/software centers through the concept of a union catalog and also local catalogs. A DCS architectural design will be completed in Phase I. A prototype of this design will be incorporated into a single package consisting of the DCS, DAVID, and AutoLib X-Windows system. The package will demonstrate the feasibility of accessing and updating distributed catalogues over a single consortium. Phase II will generalize the implementation of DCS to multiple consortiums and will enhance the user interface.

Potential Commercial Applications: This product has major potential commercial utility in many fields including distributed medical databases, distributed GIS systems, and commercial information bases.

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128 GSFC
91-1-07.06-3666 NAS5-31880
Ultra-Fast, Ultra-Dense, Radiation-Hard, Non-Volatile GaAs Random Access Memory
Electro-Optek Corporation
3152 Kashiwa Street
Torrance, CA 90505
V.K. Raman (310-534-3666)

A radiation-hard, non-volatile random access memory (RAM) using an epitaxial, InSb Hall element fabricated on gallium arsenide (GaAs) in conjunction with a thin-film layer of permalloy will be developed. The permalloy layer serves as the non-volatile memory storage medium, while the InSb Hall element acts as the high-speed memory readout. The RAM can be built by very large scale integrated-circuit (VLSI) technology. First, a special molecular beam epitaxy process for growing a high-mobility epitaxial, InSb layer on GaAs will be developed, followed by the development of a thin layer of a Ni:Fe permalloy on top of the InSb to form the memory cell. The densely packed memory cells will then be integrated into high-electron-mobility transistor (HEMT) circuits previously processed on the GaAs to complete the non-volatile RAM array. By virtue of InSb's high mobility and extremely fast, low-noise HEMT driver, an access time less than 5 nanosecond and a packaging density greater than 1M bit/cm^2 are achievable. These characteristics are superior to those of the state-of-the-art static, non-volatile RAM. Because the magnetization of the permalloy is not affected by high-energy radiation and the entire structure is built on a semi-insulating substrate, this RAM is radiation hard--well in excess of the equivalent of 10^8 rad(Si) of total dose. It is ideally suited for spacecraft-based data management and storage systems deployed in a combination of Van Allen belts, solar-flare and cosmic-ray radiation environments for 10 years or longer.

Potential Commercial Applications: The main applications are high-density static RAM for high-speed computing and for spaceborne and defense computer systems requiring immunity to nuclear radiation damage.

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129 JPL
91-1-07.06-7565 NAS7-1180
High-Density, Optical Data Storage in a Novel, Flexible Medium with Built-In Focusing Microspheres
Moltech Corporation
Engineering Bldg - SUNY
Stony Brook, NY 11794-2275
V.F. Dorfman (516-632-7565)

Traditional digital optical information storage processes place stringent requirements on the flatness of the storage medium and on the alignment during information storage and retrieval. In contrast, this project seeks to develop a novel, highly flexible information storage and retrieval scheme based on focusing light using

monodisperse transparent microspheres. The size of the spheres, combined with their inherent ability to reduce the effects of lateral misalignment, lead to relaxed overall mechanical precision requirements by one to two orders of magnitude compared to traditional optical data storage media. To fully realize the potential of this technique, "burn films" and protective coatings with a high degree of mechanical and chemical resistance need to be developed. The main goal of this project is to develop a new class of "burn films" and protective coatings based on diamondlike nanocomposite technology developed at the firm. Extensive experimentation has shown that this new class of materials has excellent chemical, mechanical, and thermal resistance. In addition, the potential for incorporation of a gray scale in these materials based on changes in transmittivity and/or reflectivity induced by laser irradiation will be investigated.

Potential Commercial Applications: A highly flexible, inexpensive, and compact optical data storage systems would be useful for a wide variety of applications. Further, the incorporation of a gray scale in the optical storage medium will result in significantly higher optical data storage capacity than presently available.

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130 JPL
91-1-07.06-9327 NAS7-1166
Vertical Bloch-Line Memory-Bit Stabilization
Revtech, Inc.
23520 Telo Street, Unit 13
Torrance, CA 90505
Aram Tanielian (310-530-9327)

Vertical Bloch-line (VBL) memory is a recently conceived, integrated, solid-state, block-access, VLSI memory that offers simultaneously the potential of 1 GBit/cm^2 areal storage density, gigabit per second data rates, and submillisecond average access times at relatively low mass, volume, and power values when compared to alternative technologies. VBLs are micromagnetic structures within magnetic domain walls, which can be manipulated using magnetic fields from integrated conductors. The presence or absence of VBL pairs are used to store binary information. At present, efforts will be directed at the feasibility of VBL bit stabilization by a confinement pattern of cobalt-platinum films or by modulating grooving using sloped and straight 90°0 grooved walls in place of hard magnetic film like Co-Pt. Efforts also will be directed to fabricate VBL devices on large lattice garnet substrate with heavily bismuth-doped Epi to enhance observability of Bloch lines, because of its large Faraday rotation, to study the motion of bubble domain.

Potential Commercial Applications: The VBL memory is a solid-state replacement for hard disk and tape recorders with 100 to 3000 MBit/chip access times of 0.1 sec. to a few millisec., and data rates up to hundreds of MBit/sec at 0.1 watt/(MBit/sec) or very small (1 cm^2 chip).

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131 MSFC
91-1-07.07-3474 NAS8-39310
A Hybrid, Neural-Network and Expert-System Approach to Remote Sensing
Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, MA 02138
James M. Mazzu (617-491-3474)

The integration of artificial neural networks (ANNs) and knowledge-based expert systems is an ideal step in the development of intelligent systems. In general, the two methods complement each other such that ANNs provide "soft" constraints, while expert systems allow "hard" constrains. Specifically, ANNs can perform nonlinear functions, pattern recognition, fault-tolerance, and parallel processing; while expert systems involve language processing, formal logic, and rule interpretation. The complementary strengths of neural-networks and knowledge-based expert systems will be used to create a hybrid remote sensing system that can outperform either method alone. An advanced remote sensing system within a hybrid neural-network/expert system environment will be developed to be incorporated in the Geostationary Earth Observatory. The system will take advantage of both ANNs and expert systems to handle global and local event isolation and identification, measurement validation, instrumentation control, and information storage. The hybrid remote sensing system will be implemented within the hybrid NueX shell, providing a visual object-oriented development environment for real-time remote sensing applications.

Potential Commercial Applications: The commercial application will be a tool for a hybrid remote sensing system applications by aerospace prime and subcontractors, government, and university research laboratories.

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132 MSFC
91-1-07.08-1188 NAS8-39339
Hybrid, Multiple-Object-Recognition System for a Laser Radar Image
Sigmatech, Inc.
4810 Bradford Drive
Huntsville, AL 35805
James Hereford (205-721-1188)

A new approach to object recognition that combines optical correlation with a syntactical pattern classification system based on fuzzy-set theory to discriminate among objects will be developed. The optical system allows large amounts of data to be processed in parallel, thus reducing the computational load on the electronic

pattern classifier. In particular, the data can be preprocessed to eliminate salt and pepper noise, reject debris, or reduce broadband, white noise. Specific features or sub-patterns will be identified using the optical correlation system, and these features are then passed to the fuzzy set syntactical classifier. Syntactic pattern classification recognizes an object by the detection, orientation, and spatial relationships among its constituent parts. The use of fuzzy set methods permits nonexact or ambiguous information to be included in the classification of objects and allows the decision itself to be fuzzy, thereby allowing qualitative decision making similar to human experts. Such a system can be used with a scanning laser radar input to detect and track multiple objects in space for either rendezvous and docking or collision avoidance.

Potential Commercial Applications: Commercial applications include multiple object recognition, automated inspection of parts/quality control, machine vision, and speech recognition.

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133 MSFC
91-1-07.08-5540 NAS8-39334
Optical Edge Sensors for Large-Aperture, Segmented Arrays
Quantametrics, Inc.
Brackenwood Path
St James, NY 11780
John L. Remo (516-584-5540)

This project will address a method to accurately and rapidly measure piston and tilt between small segments of a large aperture telescope by an actively mode-locked semiconductor laser diode. The size of these segments approximates that of a disturbance coherence dimension associated with the wavelength of interest. Such sensors are critical to state-of-the-art adoptive optics sensing, actuation, and control techniques, which can lead to low-cost fabrication methods over a large scale. The goal of this project is to develop a semiconductor laser that can be modulated by an external cavity to change threshold current levels and evanescent scattering. Phase I will develop a breadboard model.

Potential Commercial Applications: Applications include consumer, industrial, and medical electronics.

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134 GSFC
91-1-07.10-9302 NAS5-31935
A Non-Volatile, Solid-State Recorder for Spacecraft
SEAKR Engineering, Inc.
4030 Spencer Street, Suite 108
Torrance, CA 90503
Scott R. Anderson (310-542-9302)

A non-volatile, highly reliable, solid-state recorder (SSR) to be used on future spacecraft in place of tape recorders will be developed. The SSR will be microprocessor controlled and easily expandable to high capacity, and will successfully operate in the environment of low-Earth orbit. Tape recorders have been used in spacecraft to store mission and/or telemetry data ever since the first satellites were launched in the fifties. The tape recorder has served a very useful and necessary function; however, because of the mechanical tape transport system of tape recorders, they have demonstrated reliability and life problems. Redundancy has been used to overcome these reliability problems. For example, the Air Force DMSP uses four 1.7 Gbit tape recorders to assure that at least one is working at the end of the mission; however, this is costly in terms of both dollars and launch weight.

Potential Commercial Applications: Most satellites presently use tape recorders. Just last year the European Space Agency, through NASA, contracted for fourteen 1 Gbit tape recorders for the ISTP mission. The French Spot satellite uses similar tape recorders. After demonstration of orbital operation of this SSR, all satellites will use it instead of tape recorders. This is a 20-to-30 million dollar a year market.

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135 ARC
91-1-07.11-1414 NAS2-13527
Effective Identification of Radio-Frequency Interference for the Search for Extraterrestrial Intelligence
DSP General, Inc.
5655 Lindero Canyon Road, Suite 304
Westlake Village, CA 91362
Patrick J. Ready (818-597-1414)

False alarms due to radio-frequency interference (RFI), such as manmade communication signals, are a very real contributor to a reduction in the system performance of the multichannel spectrum analyzer for the search for extraterrestrial intelligence (SETI-MSCA). RFI may even mimic the true signals of interest. The use of novel cyclostationary ambiguity transform (AT) processing will provide a practical processing technique to identify and characterize RFI present in the observation bandwidth. Moreover, this prescreening process will provide the key RFI parameters even if the RFI is far below the ambient noise. The RFI parameters will then be used by the MCSA to significantly reduce associated false alarms. Phase I will identify potential RFI, quantify the theoretical AT performance against RFI, and develop a preliminary design of the AT processor itself. Phase II will finalize the preliminary design and build a prototype for test and for evaluation in the SETI-MCSA system.

Potential Commercial Applications: Applications are possible in NASA communications systems in which symbol synchronization and/or RFI identification and

characterization are important, e.g., deep space communications.

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08: Instrumentation and Sensors

136 GSFC
91-1-08.01-1667 NAS5-31883
Ultra-Lightweight, Large-Aperture, Space-Based Telescope
OCA Applied Optics, Inc.
P.O. Box 3115
Garden Grove, CA 92642
Ying W. Hsu (714-895-1667)

A methodology will be developed for the design and fabrication of large aperture (0.75 to 1.0 meter), ultra-lightweight optical receivers for space sensing applications. In this approach, a systematic study of the design and manufacturing technology for such structures, specifically investigating innovative solutions to the limitations imposed by the conventional rules of telescope design and manufacturing, will be conducted. A recent trade study indicates that it is possible to achieve significant weight reductions of 20 percent to 40 percent if more precise design techniques and newer fabrication methods are employed. However, specific data is needed to characterize and control risk for such designs, particularly for large aperture telescopes. During Phase I, these outstanding issues will be addressed, specifically with respect to the need for a 0.75 meter or larger diameter, ultra-lightweight space telescope.

Potential Commercial Applications: The successful completion of Phase I would result in a significant new capability for the design and fabrication of ultra-lightweight optical telescope assemblies. Success in Phase I and Phase II will incorporate these enhanced capabilities into the company's broad spectrum of optical fabrication capabilities, enabling routine and cost-effective production of high-performance, ultra-lightweight optical components for end-users including NASA, DOD and DOE.

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137 GSFC
91-1-08.01-1802 NAS5-31921
Low-Voltage Spaceborne Q-Switch
Schwartz Electro-Optics, Inc.
3404 North Orange Blossom Trail
Orlando, FL 32804
John G. Daly (407-298-1802)

Diode-pumped, solid-state lasers will require small, low-voltage, reliable Q-Switch devices. Compact high-energy lasers will have narrow beam waists necessitating components with high resistance to optical damage. The company's extensive experience in electro-optic devices has led to the development of $LiNbO_3$. Its availability, optical quality, high electro-optic coefficient, non-hygroscopicity, and low-voltage requirements favor its selection as the leading candidate for spaceborne missions. In a small package compatible with diode-pumped solid-state lasers, the quarter-wave voltage can be as low as 168 volts. The only drawback to $LiNbO_3$ is its susceptibility to laser damage. Conventional anti-reflection, thin-film coatings provide resistance to damage typically from 300 to 600 Megawatts/cm^2. A new thin-film coating process (Q-Plate) that has been successful on a number of optical coatings will be evaluated. Damage threshold measurements and laser and performance testing in a new, space-compatible Q-Switch mount will be conducted.

Potential Commercial Applications: The laser industry has always suffered from reliability problems related to optical damage. This normally defines the limits for laser systems. On its own merits, improvements in the anti-reflection coating for $LiNbO_3$ will benefit the entire industry and all military laser systems.

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138 SSC
91-1-08.02-1119 NAS13-485
Airborne System for Remote Sensing of Soil and Subsoil Parameters
Barringer Patents, Inc.
25060 Montane Drive West
Golden, CO 80401
Anthony R. Barringer (303-526-1119)

The project deals with a helicopter-borne geophysical and remote sensing system that integrates two subsystems for generating electromagnetic fields covering a very broad frequency spectrum from 100 Hertz to 1 gigaHertz, or higher. Innovative techniques are used to probe the Earth down from the surface to 30 meters and to provide compensation for surface scattering effects in the higher frequencies. Conductivity and dielectric constant measurements provide information on the subsurface characteristics. The project objective is to provide the detailed design parameters for an operational system and to explore and verify certain concepts for use on the suppression of surface scattering. A program will be defined to achieve these objectives involving some assembly of equipment and specific types of field tests to be performed. Verification of the basic concepts to be used is anticipated and included will be the assessment of ground conditions down to 30 meters in areas of interest to NASA. Also, the potential future development of radars capable of measuring soil moisture over large areas either from aircraft or from space will be assessed.

Potential Commercial Applications: Results would be applicable in surveys of wetlands and semi-arid terrains measuring soil salination and saltwater intrusion; measurement of soil moisture in near-surface and at

depths for agriculture, irrigation control, gravel resource exploration; surveys of routes for roads and pipelines, and permafrost assessment; and crop forecasting.

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139 GSFC
91-1-08.03-1416 NAS5-31936
Large-Aperture, High-Resolution, Tunable, Fabry Perot Etalons
Physical Optics Corporation
2545 West 237th Street, Suite B
Torrance, CA 90505
Gajendra Savant (310-320-3088)

A prototype large-aperture, high-resolution Fabry-Perot (FP) etalon, which uses holographic coherently coupled cavity mirrors with phase conjugate enhanced recording techniques, will be designed, fabricated, and tested. The firm has recently shown, theoretically, that holographic Fabry-Perot (HFP) etalons can achieve one-to-two orders of magnitude better finesse and contrast when compared with conventionally coated Fabry-Perot etalons for a given substrate quality. Also, because of the nature of the recording of the holographic mirrors, they can be fabricated over large areas, and consequently very-large-area FP etalons of significantly greater throughput will result. This technological breakthrough also promises to be relatively easy to fabricate and consequently should yield a cost-effective end item. An excellent application of these HFPs will be to the detector stage of LIDAR systems for earth atmospheric remote sensing. As a consequence of using this new technology, NASA systems for LIDAR, DIAL and Doppler measurements should realize improvements of signal/noise ratio in the range of 3 to 10. In addition, daytime performance of a number of these systems will be attainable.

Potential Commercial Applications: Commercial applications for the HFP etalons will be to ground-based LIDAR, DIAL and Doppler systems for environmental measurement and compliance. FTIR, Raman spectroscopy, and fiber optic wavelength division multiplexing will improve their performance as a result of incorporation of this new large aperture high-resolution filter.

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140 LaRC
91-1-08.04-0003 NAS1-19536
Quadrupole Traps for Optical Characterization of Aerosols
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Karen Carleton (508-689-0003)

A quadrupole trap coupled with optical diagnostics for in situ characterization of size distributions, composition, and optical properties of aerosols will be developed as a small, compact flight instrument. Particle mass will be measured from the quadrupole-trap balance voltage and correlated with particle size determined from the Mie scattering-polarization ratio. The trap design will include optical access to implement a variety of particle diagnostics including angular-and-polarization dependent Mie scattering for optical properties and Raman scattering for particle composition.

Potential Commercial Applications: A quadrupole trap with optical diagnostics could be developed as a flight instrument for in situ aerosol characterization, as well as a particle monitor for pollution control.

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141 SSC
91-1-08.05-7445 NAS13-479
Sensor Calibration System Design
Cimarron Computer Engineering, Inc.
1416 Caballero Drive SE
Albuquerque, NM 87123
John M. Hickey, III (505-275-7445)

A fully automated, field-related apparatus to calibrate visible and infrared systems in airborne applications will be developed. Several manufacturers produce test equipment, but no one apparatus can presently perform the multitude of individual tests in a correlated and automated manner. This innovation not only calibrates airborne sensor systems but does so using menu-driven software for complete user flexibility; displays results on a CRT for immediate review; prints a hard copy of test results; and produces a floppy disk record of the raw data for later replay or comparison with subsequent data. The software will allow user selection of the available wavelength, tests, and specifications of the particular sensor. Data from the sensor under test will be fed into the analysis computer over a common interface, such as the IEEE-488, in a preselected format for assimilation.

Potential Commercial Applications: The result can be marketed as a military sensor calibration system or a commercial sensor calibration system.

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142 LaRC
91-1-08.06-3772A NAS1-19544
Lutetium-Aluminum-Garnet and Yttrium-Scandium-Garnet for 2.1-Micron Lasers
Scientific Materials Corporation
310 Icepond Road
Bozeman, MT 59715
Ralph L. Hutcheson (406-585-3772)

Modeling has indicated $Lu_3Al_5O_{12}$ and $Y_3Sc_2Al_3O_{12}$, both garnets, would make superior hosts for holmium for 2.1μ lasers. Both materials require innovative crystal growth to improve quality and laser rod yields. The low-scatter crystal growth methods developed for the growth of high-quality Nd:YAG should provide the results

necessary to produce crystals of appropriate size for both diode- and flash-pumped lasers.

Potential Commercial Applications: Applications includes LIDAR for wind-shear detection and also medical lasers.

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143 MSFC
91-1-08.07-6250 NAS8-39336
Geostationery Optical System for Use as an Imager or Infrared Sounder
Research Support Instruments
10610 Beaver Dam Road
Cockeysville, MD 21030-2288
John C.E. Berends, Jr. (301-785-6250)

The project objective is to design a geostationary optical system that can serve as either an imager or infrared sounder. The GOES imager and sounder utilizes a spinning satellite with very little efficiency in scanning. The innovation would allow almost 100 percent scan efficiency and give the option to scan rectangular sections for rapid repeat coverage of limited, rectangular area for events such as severe storms. In particular, the innovation concentrates on reducing the problems caused by direct sunlight entering the optical cavity. Direct sunlight would see only the scan mirror portion of the optics. That mirror would not reflect highly energetic ultraviolet, x-ray, and particulate emission from the sun into the telescope assembly. The scan mirror could be two-sided so that, after prolonged solar exposure, it could be rotated 180 degrees and a new mirror face could be utilized.

Potential Commercial Applications: This design could assist NASA in the design of the GOES Next-Next and would also provide a basis for bidding on similar sensors for countries, such as India, which rely on countries such as U.S. for satellite hardware.

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144 MSFC
91-1-08.07-8211 NAS8-39326
Real-Time, Self-Contained, Image-Motion Compensation for Spaceborne Imaging Instruments
Irvine Sensors Corporation
3001 Redhill Avenue, Building 3, Suite 208
Costa Mesa, CA 92626
Jack L. Arnold (714-549-8211)

This innovation is a densely packaged image motion compensation (IMC) processor on the focal plane of imaging instruments, constructed using three-dimensional, focal plane architecture. Image motion is sensed directly from the instrument images, and compensation is achieved by electronically registering them to the initial frame in the sequence prior to integration to build an image. The work is relevant to GEO missions because of the extremely long integration times and high resolution of the imaging instruments. Program objectives are the analytical validation of the approach effectiveness and the demonstration of a realizable design specification. The effort will include a calculation of the effectiveness of the smear removal and the design of focal plane components and a low-risk demonstration system to the level of a detailed specification. The anticipated results are an analytical demonstration of effectiveness and design specifications for realizable flight focal plane and lab demonstration systems. NASA applications include any imaging system that requires a stabilized platform such as earth observation, spaceborne astronomy, and interplanetary imaging science.

Potential Commercial Applications: Commercial applications are the fields of astronomy, astronomical navigation sensors on moving platforms, robotic vision, and surveillance from moving platforms.

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145 JPL
91-1-08.08-2650 NAS7-1159
Tunable Diode Lasers for Airborne Spectrometers for Atmospheric Sensing
Laser Photonics, Inc., Analytics Division
25 Wiggins Avenue
Bedford, MA 01730
Ze'Ev Feit (617-275-2650)

Infrared absorption analysis utilizing lead-salt tunable diode laser (TDL) sources is an extremely powerful technique with broad, general applications. Nearly all molecular species exhibit characteristic infrared absorption toward the long wavelength infrared range (IR) accessible to TDL technology. However, widespread acceptance of the technology has not occurred primarily due to the cost and complexity arising from diode-laser properties--low temperature operation and multimode operation. Thus far, the firm has demonstrated the feasibility of buried heterostructure PbEuSeTe lasers operating in the 3 μm to 6.5 μm spectral range with an operating temperature in excess of 77 K. The project objective is the development of this technology for PbSnTe active layers and the production of a buried heterostructure diode-laser emitting at 7.5 μm operating in continuous wave mode at a temperature above 77 K.

Potential Commercial Applications: The development of mid-IR diode lasers capable of operation above 77 K in the 6.5 to 13 μm range will lead to many applications that have been previously precluded by stringent cryogenic cooling requirements. Commercial applications include low-cost, high-performance systems for industrial and air pollution monitoring, medical diagnostics, and other analytical applications.

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146 JPL
91-1-08.08-3666 NAS7-1184

Tunable, Infrared, Diode-Laser Arrays for High-Performance Spectrometers

Electro-Optek Corporation
3152 Kashiwa Street
Torrance, CA 90505
C.F. Huang (310-534-3666)

Double heterojunctions (DH) PbS/PbSSe/PbS diode laser arrays will be developed as tunable infrared radiation sources covering the 3 to 5 mm waveband. Using molecular beam epitaxy (MBE) bandgap engineering, the PbSSe epitaxial layer will be tailored for a specific wavelength and engineered as an active well region sandwiched between two PbS cladding layers. The injected electron-hole pairs will be confined to this well region for higher operating temperature and lower threshold current in lasing. Two PbS/PbSSe superlattices, also fabricated by MBE, will be used as distributed Bragg reflectors (DBR), sandwiching the DH laser to form the resonance cavity. Thus the laser will emit radiation perpendicular to the surface of the substrate, allowing a simple configuration for structuring a two-dimensional array of lasers emitting from the surface. The multiple-layer growth will be made on a silicon (Si) substrate buffered with a mixed-fluoride epitaxial layer to match the lattices of Si and PbS/PbSSe/PbS laser structure. Lattice matching between the DBR and the DH structures will be made by controlling the periodicity and composition of the interfacial defects, junction leakage, and nonradiative carrier absorption, leading to an increase in lasing efficiency and device yield. Phase I will model and design the DH structure; design the MBE sources and fixtures needed for epitaxy; demonstrate the feasibility of buffer epitaxy; and demonstrate the feasibility of PbSSe epitaxy on buffered Si. Phase II will be devoted to the development of the DBR and the fabrication of the DH laser structure.

Potential Commercial Applications: Applications may result in electronic countermeasures, active imaging, missile guidance, optical computing, and designators.

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147 JPL
91-1-08.08-9500 NAS7-1171

A Tunable, Infrared Source for Molecular Spectroscopy Using Room-Temperature Diode Lasers

Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
Roger S. Putnam (508-663-9500)

Laser sources currently available for molecular spectroscopy in the 2 to 30 micron region are lead-salt diode lasers cooled to liquid-helium temperatures. They typically produce ten modal frequencies at once. These problems require a monochromator just to clean up erratic tuning behavior of the laser source and a $60,000 system for closed circuit cooling, electrical control, and optics. Despite these problems, the importance of these wavelengths in detecting trace species as diverse as greenhouse gases such as methane from swamps to nitrous oxide from combustion processes has forced many researchers to use these unwieldy laser sources. The opportunity here is to apply inexpensive, tunable, room-temperature diode lasers; these are now readily available with enough power to directly drive a nonlinear difference-frequency infrared generator when previously $35,000 dye lasers were required. The fact that the new diode lasers produce enough power, are available with 10 MHz linewidths without an external cavity, are tunable, and are remarkably efficient make this application an immediate opportunity. The objectives involve the basic demonstration of generating tunable infrared radiation in the 2.5 micron region using a diode laser and a KTP crystal, and the measurement of the resulting optical linewidth. The anticipated results from Phase I include a rudimentary demonstration of gas-phase nitrous-oxide or hydrofluoric-acid detection.

Potential Commercial Applications: An inexpensive tunable source of narrowband infrared will permit the construction of air monitoring equipment for a wide variety of pollutants. The market for this instrument already exists in this period of increased social awareness and government regulations.

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148 JPL
91-1-08.09-2627 NAS7-1170

Tunable, Liquid-Crystal Filters for Remote Sensing Applications

Cambridge Research & Instrumentation, Inc.
21 Erie Street
Cambridge, MA 02139
P. Miller (617-491-2627)

Recent advances in liquid-crystal technology have enabled construction of tunable, birefringent filters with bandwidths between 1 nm and 26 nm. The center wavelength of these filters can be selected electronically in a few milliseconds with no moving parts. These liquid-crystal tunable filters (LCTF's), together with existing CCD detectors, make possible a new generation of lightweight, rugged, high-resolution imaging spectrophotometers. Such instruments would be interesting for remote sensing applications on a variety of aircraft and satellite platforms. Important advantages exist in the aperture, image stability, power consumption, size, weight, and absence of high-drive frequencies, compared with current instruments used or considered for multispectral scene analysis. Evaluation of these filters for NASA remote-sensing applications will be conducted. A filter will be built, and measurements and literature studies will be carried out to characterize the spatial and spectral imaging quality, thermal sensitivity, achievable spectral range, and level of space hardening for comparison with NASA requirements.

Potential Commercial Applications: Commercial applications would apply to microscopy, medical imaging, astronomy, and stage lighting.

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149 GSFC
91-1-08.10-3232 NAS5-31942
An Active System for Determination of Green-Leaf Area Index from Reflectance Measurements
Ressler Associates, Inc.
14440 Cherry Lane Court, Suite 212
Laurel, MD 20707
Gerald M. Ressler (301-206-3232)

A remote sensing system to estimate green leaf area index (GLAI) will be studied. The method employed relates second-derivative canopy reflectance information to GLAI values. This novel approach minimizes the effect of differences in soil substrate reflectance because most substrates have nearly zero second-derivative reflectance values near 740 nm. By removing the wavelength-resolving element in a tunable pulsed laser, the wideband output (720 nm to 800 nm) of the laser will provide enough energy across a 30 nm interval so that three reflectance readings straddling 740 nm can form a second derivative value. Since the functional relation between the second derivative and GLAI is known, the result is an approach to GLAI estimation that, unlike current ground-based methods, will allow rapid, wide-area studies and, unlike current passive techniques, should prove insensitive to diurnal cycle or source-sensor geometry. The objective of Phase I is to develop an initial design that demonstrates the feasibility of constructing such a system, including both sensor hardware and software.

Potential Commercial Applications: This system will provide NASA with a new tool for vegetation-structure analysis, providing an increased understanding of the behavior of vegetation canopies. It could ultimately result in higher crop productivity, elevated ecological awareness, and better management of earth resources. Other applications include such uses designed to estimate hydrocarbon emissions; monitor desert expansion and deforestation; identify stressed plantlife; and estimate crop yield.

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150 ARC
91-1-08.10-5649A NAS2-13507
Airborne Multispectral Polarization Imager
Daedalus Enterprises, Inc.
P.O. Box 1869
Ann Arbor, MI 48106
Steven D. Cech (313-769-5649)

This effort will investigate the feasibility of designing and fabricating a passive, airborne, multispectral polarization imager. This system will operate in a pushbroom, line-scanner mode using multiple, linear, silicon arrays to acquire scene polarization data. This system will acquire enough information to allow the determination of the first three Stokes parameters of the reflected scene energy. To date, multispectral polarization data has been collected using single-point profilers or film-based analog image recording techniques. The innovation of the proposed instrument will be to extend the power capabilities of airborne, digital scanner systems to include polarization selective detection. A polarization scanner system has shown potential in the determination of leaf area index, as well as plant development stage, leaf water content, and crop damage or disease.

Potential Commercial Applications: It is anticipated that this instrument will find application in all commercial remote sensing programs involving precise measurements of reflected or emitted electromagnetic fields.

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151 GSFC
91-1-08.10-8442 NAS5-31918
Versatile, Holographic, Optical Element for High-Resolution Spectroscopy
Applied Research Corporation
8201 Corporate Drive, Suite 1120
Landover, MD 20785
Hemant H. Dave' (301-459-8442)

Fabry-Perot (FP) interferometers are routinely used to measure upper atmospheric wind velocities, temperature differences, and weak emissions from astronomical objects. For a given wavelength, etalon plate spacing, and index of refraction of medium between the plates, the output is an interference pattern of concentric rings. The conventional method utilizes only the central portion of the Airy-disk pattern. Theoretically each ring carries the same light intensity; therefore it is obvious that the throughput of the system will increase dramatically if one utilizes many rings. Conventional ways of using multiple annular apertures or multiple detectors and thick focusing lens do not offer any extra benefits. A holographic optical element (HOE) will be developed to replace the lens, aperture, and filter in a FP interferometer. The new HOE is expected to enhance performance dramatically.

Potential Commercial Applications: The successful completion of this project will result in a new generation of imaging lenses for high resolution spectroscopy. Potential applications exist in plasma research, monochromators, astronomy, remote sensing, x-ray microscopy, and neutron imaging.

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152 GSFC
91-1-08.11-1112 NAS5-31924
A High-Sensitivity, Charge-Coupled-Device Readout Technique
Q-Dot, Inc.
1069 Elkton Drive
Colorado Springs, CO 80907-3579
David W. Gardiner (719-590-1112)

The low-noise performance of charge-coupled-device (CCD) imagers and signal-processing devices is presently limited by the performance of the associated charge-sensing amplifiers. Typical amplifiers show noise levels of 100 to 200 electrons/packet and gains of 1 to 5 μV/electron. The transverse floating-gate FET investigated in this project will circumvent the gain-limiting stray capacitance and permit the development of amplifiers with 100 to 200 μV/electron gain with noise levels of less than five electrons. The design of the device involves the integration of a PNP FET directly above the active buried-channel region of the CCD. The PNP drain current travels across the surface of the CCD channel and is modulated by passing the buried-channel CCD charge packets under the FET. The doping profile of the device is designed to isolate the holes in the transverse FET current from the electrons in buried-channel CCD charge packets. The operating frequency of the device is limited by the width of the CCD channel, but is expected to provide operation at 1 - 10 mega-samples (Ms/s) per second with 10,000 electron charge capacity.

Potential Commercial Applications: The high gain and low noise of the proposed transverse floating-gate transistor is applicable to virtually all high-performance CCD devices. In addition to improving the sensitivity of CCD amplifiers, the device is an excellent building block for the development of charge-mode analog-to-digital converters with 10 to 20 electron least-significant-bit performance.

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153 GSFC
91-1-08.11-1190 NAS5-31944
Superconducting Thermal Detectors for High-Resolution X-Ray Spectroscopy
Hypres, Inc.
175 Clearbrook Road
Elmsford, NY 10523
David Osterman (914-592-1190)

The analysis of the spectra of astrophysical x-ray emissions gives unique information about their sources. A limiting factor in performing the analysis is energy resolution for typical low x-ray intensities. The optimum energy resolution is now achieved by semiconductor bolometer detectors operating below 1 K. The project objective is to design, fabricate, and test improved versions of these devices that use superconducting sensors rather than semiconducting ones as thermal detectors. The chief advantage is lower intrinsic device noise that will permit an energy resolution of 10 eV or less at an operating temperature T = 0.3 K. The detection mechanism is the variation with temperature of the kinetic inductance of a superconductor. The sensor element is a superconducting meander. Changes in the meander inductance are read out by a dc SQUID with its input connected to the meander. To maximize the temperature rise from absorbed x-rays, the meander element is suspended by low-thermal conduction legs from a cold block. The legs and cold block are formed from a micromachined silicon substrate. Phase I will address all significant design issues including the best superconducting material for the meander. Phase II will fabricate and test the device.

Potential Commercial Applications: An energy dispersive x-ray detector with an energy resolution of 10 eV or less will be of great use to materials analysis by x-ray fluorescence. The detector will combine the high resolution of present wavelength dispersive methods with the low-intensity capabilities of energy dispersive techniques.

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154 GSFC
91-1-08.11-2033 NAS5-31913
High-T_c Superconductor Bolometer Arrays
Energy Science Laboratories, Inc.
6888 Nancy Ridge Drive
San Diego, CA 92121-2232
James R. Clinton (619-552-2032)

The project objective will be to advance recent developments that apply high-T_c superconductor films to infrared bolometric detectors. If such detectors are to be useful, 1/f noise must be minimized, and improved thermal isolation methods must be developed. Superconductor films and improved metal contacts will be deposited by ion-beam sputtering. To lower the heat capacity of the detector structure, a new technique that the firm has developed will be utilized for substrate processing. The technique produces ultrathin but sturdy membranes. This concept is compatible with subsequent development of linear or rectangular detector arrays.

Potential Commercial Applications: The primary application is to infrared radiation detection in spaceborne and ground-based instruments. Potential applications will initially utilize single-element detectors and later utilize linear and rectangular arrays.

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155 GSFC
91-1-08.11-9937 NAS5-31912
Redeposition of High-T_c Films on Diamond for Infrared Detectors

Neocera, Inc.
335 Paint Branch Drive
College Park, MD 20742-3261
Roger Edwards (301-314-9937)

For space applications, high-T_c infrared detectors on diamond substrates would be ideal from the point of view of sensitivity. However, with current techniques it is difficult to fabricate low-noise (high-quality) films directly on diamond. A technique will be developed to accomplish this whereby high-quality films are first grown on a different substrate material, followed by selective removal of that material, leaving well-oriented free-standing high-T_c films. The films can then be redeposited on diamond for subsequent fabrication of detectors. The approach will require finding substrate materials that can be chemically etched without affecting the high-T_c material. A prime task will be to demonstrate that good, quality high-T_c films can be grown on such substrates, with an appropriate buffer layer, if necessary, to alleviate interface problems such as chemical interaction. After redepositing the films on diamond, their electrical noise and optical response will be measured to demonstrate the feasibility of fabricating high-performance infrared (IR) detectors by this technique.

Potential Commercial Applications: The ability to form free-standing high-T_c films could lead to the following commercial applications: IR detectors on diamond substrates; IR detector arrays and a generic technology for the deposition on high-T_c films on any custom substrate for the eventual fabrication of microwave devices, flexible conductors, and EMI shields.

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156 GSFC
91-1-08.12-6000 NAS5-31930
Long-Wavelength, Gated, Mercury-Cadmium-Telluride, N+N-P, Photodiodes for Heterodyne Applications

Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Nasser H. Karam (617-275-6000)

High-sensitivity, wide bandwidth, photomixers operating at 15 to 30 microns are of great interest for applications that range from the detection of molecular species, both within the atmosphere and in outer space, to the determination of wind velocities and distribution from satellite-based systems. HgCdTe photodiodes are the detector of choice because of their tunable band gap. Previous investigations in this area concluded that better surface passivation and material quality were required to improve device performance. By applying state-of-the-art CdTe passivation to a gated N+N-P detector structure on MOCVD HgCdTe, control of the surface leakage currents that can degrade device performance will be achieved. Phase I will demonstrate the photodetector structure on CdTe substrates and will determine its heterodyne sensitivity by analysis of variable temperature data. Phase II will apply the same structure to HgCdTe grown on GaAs and/or GaAs on Si substrates by MOCVD. Selective area epitaxy will be utilized for the fabrication of monolithic HgCdTe photomixers and preamplifiers for faster, more compact, lighter detectors with superior performance and radiation resistance.

Potential Commercial Applications: Improved and more producible long wavelength photomixers will find their way into a variety of instruments in which heterodyne radiometry is applied. These will include infrared spectrometers, gas analyzers for field use, and LIDAR systems for the detection of localized atmospheric disturbances (such as wind shear).

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157 JPL
91-1-08.13-4661 NAS7-1181
A Monolithic, InGaAs-FET Detector Array for Near-Infrared Imaging

Sensors Unlimited, Inc.
51 Cherry Brook Road
Princeton, NJ 08540
Gregory H. Olsen (609-466-4661)

The project objective is to develop a monolithic room-temperature imaging system for the 1.0 μm to 3.0 μm spectral region. This innovation consists of a novel "quasi-planar" field effect transistor (FET) switch integrated with a fully planar, passivated $In_{.8}Ga_{.2}As/InAs_{.6}P_{.4}$ detector. Phase I will consist of fabricating the combined device as an 8-element $In_{.53}Ga_{.47}As/InP$ linear array for 1.0 μm to 1.7 μm and of demonstrating its spectral, speed, and noise properties. The Phase II effort will entail making 256-element linear and two-dimensional arrays and demonstrating their imaging properties out to 3 μm.

Potential Commercial Applications: The present imaging systems for the 1.0 to 3.0 μm wavelengths require cryogenic cooling and cost tens of thousands of dollars. Successful development would lead to a room-temperature imaging system with a maximum cost of a few thousand dollars. Specific applications would include hand-held infrared cameras, improved near-infrared spectrometers for chemical identification and process control, and satellite imaging for remote sensing of atmospheric gases such as methane, water vapor, and carbon dioxide.

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158 ARC
91-1-08.13-6700 NAS2-13516
Silicon-Nitride, Membrane Bolometer for Operation at Helium-3 Temperatures
Conductus, Inc.
969 West Maude Avenue
Sunnyvale, CA 94086
Michael J. Burns (408-737-6705)

An array-compatible phonon-noise-limited bolometer will be developed for operation at He_3 temperatures and optimized for low-background applications. The bolometer is innovative in three respects: It will employ a silicon-nitride membrane with a very low thermal conductance, approximately 8×10^{-11} W/K, thereby achieving an NEP of 2×10^{-17} W/√Hz, approximately a factor of ten better than the most sensitive available He_3 temperature bolometers. It will read out the signal with a SQUID amplifier, and it will expand the dynamic range of transition-edge bolometers by using the thermometer as a null detector in a feedback loop. These low-background, high-performance detectors could be used on infrared astronomy satellites such as the forthcoming Space Infrared Telescope Facility, the submillimeter moderate mission, the Kuyper Airborne Observatory, or SOFIA.

Potential Commercial Applications: The bolometer will find applications in laboratory photospectrometers.

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159 JPL
91-1-08.14-0126 NAS7-1167
A One-Gigahertz, 256-Channel, Low-Power, Single-Chip, CMOS Digital Correlator Spectrometer
Spaceborne, Inc.
742 Foothill Boulevard, Suite 2B
La Canada, CA 91011
C. Timoc (818-952-0126)

The innovation is based on the recognition that order-of-magnitude improvements in the performance-to-cost ratio of digital correlating spectrometers can be achieved with a combination of systolic architecture, pipelined differential logic (PDL) circuits, a low-skew clock distribution network, and the standard 0.8 μm CMOS fabrication process. The objectives of Phase I are to design, simulate, lay out, fabricate, and evaluate the performance of a 1 GHz, 16-channel, CMOS correlator, which is anticipated to provide a factor of three increase in the performance-to-cost ratio relative to existing correlators. It is anticipated that this project (Phases I and II) will result in a digital correlator spectrometer with the following features: 1 gigasample per second; 256 channels; a 32-bit counter providing up to four seconds integration time at 1 GHz; 40 milliwatts of DC power per channel; and extremely small weight and size.

Potential Commercial Applications: Digital correlators are used in commercial applications such as global positioning satellite navigation receivers, wireless area networks, low-power commercial spread-spectrum communications (in three 1 W FCC bands), and cellular and cordless telephones.

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160 JPL
91-1-08.14-8181 NAS7-1177
Two-Gigahertz-Bandwidth, 2000-Channel, Acousto-Optic Bragg Cell and Spectrometer
Photonic Systems, Inc.
1800 Penn Street, Suite 4B
Melbourne, FL 32901-2625
Dennis R. Pape (407-984-8181)

Radiometer spectrometers are used in millimeter-wave radio astronomy for the spectral measurement of molecular rotational transitions. The spectrum of interest spans tens of GHz, and the measurement time to obtain a useful signal-to-noise ratio is large. The low power per channel and simplicity of acousto-optic technology has led to the current development of acousto-optic spectrometers (AOS) with 1 GHz bandwidth and 1000 channels. Additional AOS bandwidth and channelization is needed to increase spectral coverage and to reduce overall data acquisition time. The project objective is to develop a 2 GHz bandwidth, 1 MHz frequency resolution acousto-optic Bragg cell with properties, including low-optical scatter using a shear acoustic mode, required for stable AOS systems. Since other AOS components are already capable of supporting this bandwidth and channelization, the development of this new Bragg cell will result in the immediate development of a 2 GHz bandwidth, 2000 channel spectrometer, a significant advancement over current performance.

Potential Commercial Applications: Acousto-optic systems designed for applications such as real-time spectrum analysis, seismic processing, and medical imaging would benefit from the advanced performance offered by the new device described here. New developments in acousto-optic Bragg cell design can also be applied to a variety of devices used in commercial scanning technology.

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161 JPL
91-1-08.14-8551G NAS7-1160
A High-Power, Wide-Band, Synthesized Source for 90 Gigahertz
Millitech Corporation
South Deerfield Research Park, P.O. Box 109
South Deerfield, MA 01373
Chandra Gupta (413-665-8551)

Very wide-band, electrically tuned sources with coverage of at least 1000 GHz are needed for future space missions. While it is likely that these will use a chain of varactor multipliers, the driver oscillator for this chain is problematic. One approach might be to use a

Gunn oscillator in the 80 GHz to 100 GHz range, but this has severe problems in achieving a wide electrical bandwidth at the required power level. An alternative driver consisting of a high-power millimeter wave amplifier near 44 GHz followed by a doubler specially designed to handle the high input power will be analyzed. This amplifier may be driven in turn by a microwave synthesizer followed by a low-order multiplier. Wide bandwidth should be readily achieved with this approach, while tuning becomes much easier. The power consumption appears competitive with the Gunn oscillator approach and should approach the 5 W to 10 W goal. Size and weight will be small, and reliability should be excellent. The firm will design for the 90 GHz doubler with a goal of producing over 100 mW output over a 10 percent fractional bandwidth, and study the suitability of present millimeter wave power amplifiers as drivers and the problems related to the synthesizer such as spectral purity and linewidth.

Potential Commercial Applications: The application is as a key component in a wideband submillimeter local oscillator system. The system may also be used as a frequency-agile transmitter in the 90 GHz range, as a high-power swept test source, and as a driver for submillimeter radar cross section modeling systems or submillimeter materials measurement systems.

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162 ARC
91-1-08.15-2650 NAS2-13536
Thermoelectrically Cooled, Tunable, Diode-Laser Source Assembly
Laser Photonics, Inc., Analytics Division
25 Wiggins Avenue
Bedford, MA 01730
Ze'Ev Feit (617-275-2650)

Lead-salt lasers are commercially used for high resolution spectroscopy in the mid-infrared (3 μm to 30 μm) range. However, their commercial and scientific use is limited due to cryogenic cooling requirements that impose a high price and large physical size. Analysis of diode laser performances indicates that most of the fabricated PbEuSeTe/PbTe diode lasers have a maximum continuous wave (cw) operating temperature somewhat below 195 K. Evaluation of the packaging technology shows that the cold bonding technology presently used is estimated to lower the cw operating temperature by about 30 K due to the insufficient thermal contact formed when the In metal used in the bonding is pressed. The goal of this program is to develop a miniaturized, tunable, diode laser source assembly for molecular spectroscopy applications. It will be capable of emitting in the mid-infrared range of 2 μm to 5 μm when operation is in the cw mode at temperatures higher than 200 K. Keeping in mind thermoelectric cooling capability for PbEuSeTe/PbTe diode lasers, the design of a miniature new package which will take advantage of new materials and approaches. In addition, a new packaging technique based on hot bonding (soldering) will be developed taking into account the special sensitivity required in handling Pb-salt materials, which are considered the softest semiconductive materials in the industry. With this new technology, many of the fabricated diode lasers will exceed 200 K operating temperature in cw mode.

Potential Commercial Applications: The development of a miniaturized mid-IR diode laser assembly capable of operation with thermoelectric cooling will lead to many applications that have been previously precluded by stringent cryogenic cooling requirements. Commercial applications include low-cost, high-performance systems for industrial and air pollution monitoring, medical diagnostics, and other analytical applications. These include military applications in the area of communications and infrared simulators.

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163 GSFC
91-1-08.16-9621 NAS5-31932
A Spectrometer for In Situ Ocean Optical Measurements
American Holographic, Inc.
P.O. Box 1310
Littleton, MA 01460
J. Thomas Brownrigg (508-486-9621)

Accurate measurements of upwelling radiance from marine waters are needed to calibrate air- or satellite-borne sensors used to measure ocean optical properties. Submersible monochromator or filter instruments built for this purpose have several drawbacks: loss of accuracy due to mechanical wear, slow data acquisition rates, and inability to monitor several sources simultaneously. An instrument will be developed that incorporates a spectrometer with a two-dimensional, CCD array detector and permits simultaneous measurement of several sources that use optical fibers. Chlorophyll concentrations will be estimated from laser-excited chlorophyll fluorescence. The entire system, including data processing and telemetry, will be housed in an enclosure deployable from ship or buoy.

Potential Commercial Applications: This instrument would be applicable to process monitoring: on-line measurement of color, moisture, and polymer composition (visible and near-infrared); alloy composition and plasma process monitoring by element analysis; and medical diagnostics, including use of fiber-optic sensors.

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164 GSFC
91-1-08.17-0540A NAS5-31922
High-Precision Spectrometer Movement
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Richard L. Hockney (617-661-0540)

Many spacecraft optical/mechanical applications such as spectrometers require high levels of precision in positioning, precision that is unobtainable with conventional approaches. Extremely high reliability is also required. A high-precision movement for spacecraft spectrometers and other optical applications that will satisfy both of these requirements will be developed and demonstrated. The device will use a two-stage mechanism combining a novel locking, electromechanical coarse stage with a piezoelectric fine-pointing stage. The movement has complete rotational freedom about the yaw axis and allows ±5 degrees of motion about the pitch and/or roll axes. Optical components can be aligned quickly to any orientation within the allowed range of angular motion with a precision greater than .0007 arc-seconds in roll, pitch, and yaw, and held in that position indefinitely with negligible power consumption. The coarse stage combines a novel angular contact ball bearing with spherical symmetry, a spherical toque motor, and a piezoelectric locking mechanism. The fine stage is based on an extremely simple six-degree-of-freedom piezoelectric actuation system. Phase I will include design definition of the device. Phase II will construct, test, and evaluate a prototype system.

Potential Commercial Applications: A high-precision optical positioning system combining precision with small-size, low-noise, low-friction, high-stiffness, and low-consumable requirements would find immediate acceptance for both instruments and process devices in many specific industrial and military applications.

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165 GSFC
91-1-08.17-1910A NAS5-31914
Ion-Beam Polishing Technology for Grazing Incidence Mirrors
Inrad, Inc.
181 Legrand Avenue
Northvale, NJ 07647
Warren Ruderman (201-767-1910)

The collection and focusing of X rays and vacuum ultraviolet (VUV) light from the sun and other bodies in our solar system requires grazing incidence mirrors with excellent surface figures, low scatter, low surface roughness, and accurate focal lengths. The manufacture of aspheric mirrors with the required high perfection is both costly and difficult with currently available manufacturing techniques. Ion-beam polishing has recently been shown to be capable of producing high-quality surfaces on material like fused silica and Zerodu, but there is inadequate information on what other materials can be successfully polished with ion beams. This project will study the ion-beam polishing of a selected group of materials that have high potential for use as x-ray mirrors. This group consists of molybdenum, silicon, and silicon carbide in the form of single crystals, polycrystalline solids, and CVD deposited films. For each material, it will be established which materials can be ion-beam polished to the requisite figure and surface roughness. A measure will be determined of the initial surface roughness that is required for ion-beam polishing to achieve an acceptable final surface. The surface flatness, surface roughness, and subsurface damage of all samples will be measured.

Potential Commercial Applications: The successful completion of the project will provide critical information on the feasibility of ion-beam polishing of some leading candidate materials for use as mirrors in the collecting of and focusing on X rays for NASA missions. In addition the project will also establish the materials technology base that is needed for the development of an economical manufacturing technology for synchrotron mirrors.

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166 GSFC
91-1-08.17-4137 NAS5-31925
Applications of Thin Polyimide Films to X-Ray Optics
Luxel Corporation
P.O. Box 1879
Friday Harbor, WA 98250
Stephen F. Powell (206-378-4137)

Thin-films of polymeric materials are used extensively in x-ray optics as bandpass filters and proportional counter entrance windows. Although currently used materials such as polypropylene and polycarbonate have been very successful, there is a need for a new generation of materials with enhanced optical and mechanical properties. Polyimides have been suggested as candidates. A new technique for making free-standing polymer films is being developed that is particularly well-suited for fabricating thin-films of polyimides. Although the initial feasibility of such a technique has been demonstrated, many studies need to be done to characterize more fully the process and to refine the technique for manufacture. Of particular importance is the determination of the minimum thickness that may be feasibly produced by this method. Phase I innovation is a free-standing and frame-mounted polyimide film that may be metallized by dc magnetron sputtering to create composites of polyimide and a metal. It is expected that metal-polyimide composites will be available to NASA for applications in x-ray optics.

Potential Commercial Applications: The polyimide films produced in Phase I and II will have a large potential in many of the emerging applications of national importance, most notably x-ray microscopy and x-ray lithography.

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167 GSFC
91-1-08.17-7513 NAS5-31933
Integrated Filter-Detector Elements
Barr Associates, Inc.
2 Lyberty Way
Westford, MA 01886
Thomas A. Mooney (508-692-7513)

Performance of present and planned electro-optical sensors could be significantly improved with the incorporation of filters deposited directly onto detector elements. The use of ion-assisted deposition and ion-beam sputtering in the fabrication of detector filter coatings will be investigated. These processes can be carried out at a low temperature and can be used to deposit a wide variety of optical coating materials. Issues such as process, filter and detector material compatibility, patterning techniques, and risk reduction will be addressed.

Potential Commercial Applications: Principal initial applications will be in space-based sensors, in which ultimate performance, power and weight savings, and reliability are critical. Later applications include spectroscopic detector arrays with integral order sorting filters and low-cost disposable filters and sensors for patient monitoring.

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168 JPL
91-1-08.18-0700 NAS7-1173
Dynamic Evaluation of Aspheric Surfaces in Real Time
Laser Power Corporation
12777 High Bluff Drive
San Diego, CA 92130
Graham Flint (619-755-0700)

Optical systems frequently contain elements that are highly aspheric. The preferred method for manufacturing such surfaces is that of single-point diamond turning. Concurrent with the development of diamond turning, new interferometric techniques have been developed for surface evaluation. However, for surfaces that depart radically (by several hundred fringes) from spherical, routine interferometers do not have the required capability. The firm has been a leader in the application of computer-generated holograms for the assessment of aspheric surfaces. These holograms are situated internal to an interferometer and are designed specifically for each surface that is to be tested. The objective of this project involves direct incorporation of holographic interferometry into the diamond-turning process itself. The specific innovation is a technique that permits direct examination of an aspheric surface while the machine is in operation. This is accomplished by a unique combination of computer-generated holography and stop motion interferometry.

Potential Commercial Applications: Applications include miniature thermal imaging devices; uses for law enforcement; improved efficiency laser machining devices; heads-up displays; and efficient solar collectors.

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169 JPL
91-1-08.18-1166 NAS7-1188
Wide-Field Telescope with Zoom Capability for Planetary Observations
Korsch Optics, Inc.
10111 Bluff Drive
Huntsville, AL 35803
Dietrich Korsch (205-881-1166)

All-reflective, widefield telescopes for multispectral imaging with zoom and medium-resolution capability will be needed for future planetary missions. A significant zoom effect and good resolution in all-mirror systems are difficult to achieve with conventional movements of various optical elements relative to each other. The geometry of mirror systems is generally more complex than that of lens systems. This situation can be fundamentally changed by making use of the deformable mirror technology that has already reached a very high state-of-the-art. Deformable mirrors or a combination of deformable and moving mirrors eases the geometrical problems and improves significantly the degree to which the aberrations can be corrected over the full-zoom range. The goal of this project is to show that by using deformable mirrors it is possible to develop a zoom telescope design that satisfies the requirements for future planetary (including Earth) observations.

Potential Commercial Applications: This optical instrument is applicable in Earth observations and in aerial photography.

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170 GSFC
91-1-08.19-1167A NAS5-31929
Photodiode Scintillation Detector for Anti-Coincidence Shielding
Radiation Monitoring Devices, Inc.
44 Hunt Street
Watertown, MA 02172
Gerald Entine (617-926-1167)

An important goal of space research is to understand the physics involved in the activity of stars and the interactions of the sun with Earth and other planets. Increasing our understanding of solar activity can only be achieved by improving the tools and methods used to study the sun and other astronomical phenomena. Measurement of the electromagnetic emissions of the sun and stars are the primary techniques used to study them. Gamma ray and x-ray measurements are the key to understanding the internal processes of the sun. These important measurements are difficult because of the large flux of ionizing particles present in space. The interference of this particle background can be reduced using an anticoincidence shielding technique. This pro-

ject will investigate a detector that can significantly improve gamma and x-ray measurements by improving anticoincidence instrumentation.

Potential Commercial Applications: Nuclear detectors are used in scientific, industrial, safety, and medical instrumentation. The market for them is tens-of-millions of dollars; phototubes represent the major portion of this market. Avalanche photodiodes would gain a large share of the phototube market because of the photodiode's compactness, sensitivity, and reliability.

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171 GSFC
91-1-08.19-9500 NAS5-31945
Determination of the Microstructure Distribution of Aerogels in Cherenkov Detectors Using High-Resolution Spectroscopy
Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
Michael L. Burns (508-663-9500)

Through the novel applications of tunable diode laser spectroscopy, the microstructure size distribution of an aerogel that is being used as a threshold medium for a Cherenkov detector will be determined. Cherenkov detectors will be used in the Large Isotope Spectrometer for Astromag (LISA). The yield of Cherenkov photons due to traversal of a relativistic particle through the aerogel is affected by the optical dispersion and absorption length of the aerogel. The microstructure size distribution characterizes the nonuniformities in the aerogel that will affect Cherenkov photocounts. The project's objectives are to perform an experiment that demonstrates the line broadening of a gas perfused in an aerogel and to extract information about the microstructure size distribution from line measurements. Anticipated results are the realization of a spectrometer that measures the absorption line shape of a gas and the development and verification of an inversion algorithm for inverting absorption line shape measurements to find the microstructure size distribution of an aerogel sample. Expected benefits are a simple means of measuring the microstructure size distribution of aerogel in a Cherenkov detector that affects the yield of Cherenkov photocounts.

Potential Commercial Applications: Applications exist as a process control instrument for testing aerogels to be used in Cherenkov detectors.

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172 JPL
91-1-08.20-6000 NAS7-1169
High-Growth-Rate, Atomic-Layer-Epitaxy Reactor for III-V Materials
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Naser H. Karam (617-275-6000)

A new atomic layer epitaxy (ALE) reactor capable of growth rates exceeding 1 μm/hr will be designed and tested. The reactor will use continuously flowing, yet spatially separated, gas streams and a moving substrate to expose the wafer surface to alternating Group III and Group V fluxes. Its unique feature is the incorporation of both structural and gas-curtain barriers to ensure fast and efficient removal of excess reactants and reaction products. This will permit deposition to approach the very high speed inherent in the adsorption/monolayer-coverage process that could, in principle, achieve growth rates in the order of tens of micrometers each hour. Mechanical boundary layer shearing coupled with efficient hydrogen purging will prevent gas-phase mixing and degradation of ALE performance. Phase I will fit an existing reactor to a simplified reaction chamber to demonstrate high-growth rate (> 1μm/hour) ALE of gallium arsenide. Phase II will expand the system to four independent reactants and four hydrogen purge channels, making possible superlattice structures and doped alloys.

Potential Commercial Applications: The reactor's high growth rates will make it possible, for the first time, to grow complete, multi-micron thick device structures entirely by ALE. This may allow reproducible growth of uniform, strained-layer quantum wells and make possible diode lasers that emit at any desired wavelength in the range 0.5 μm to 5.0 μm.

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173 JPL
91-1-08.20-6100 NAS7-1185
Broad-Tuning-Range, Stabilized, Diode-Laser System
Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303
David Deacon (415-493-6100)

There is a market for stabilized, tunable diodes--provided the principal advantages of the diode laser (i.e., low cost, compactness, and high reliability) are maintained. Recent advances in semiconductor manufacturing technology have led to an explosion in diode laser availability across a wide wavelength range. This situation has created a market opportunity for a plug-replaceable, stabilized diode laser device. The firm has demonstrated tunable diode laser sources with high stability, compactness, and low cost. By adding the ultrastable fine alignment unit required by replaceable source lasers, the firm will extend the tuning range of a

single system to cover the entire accessible wavelength range from 0.63 microns to 2 microns and beyond. The objective of Phase I will be to modify one of the stabilized prototypes to include the alignment unit, to demonstrate that stabilized operation can be obtained for different diodes, and to measure its vibration response spectrum in order to evaluate its stability performance. Phase II will incorporate these technologies into a broadly tunable package that can be used by NASA for a wide range of spectroscopic applications.

Potential Commercial Applications: The commercial applications of this device will initially be in research. There are many low-power spectroscopy applications that will use this source directly. For high-power applications such as remote sensing of the atmosphere, this device can be used to injection seed a Ti:sapphire laser.

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174 JPL
91-1-08.21-0094 NAS7-1165
Simulation Testbed for Planetary Vehicle Imaging
Vexcel Corporation
2477 55th Street
Boulder, CO 80301
W. Kober (303-444-0095)

A prototype vision simulation testbed will be developed for use in the investigation of future planetary vehicle scenarios, such as Mars-Rover. This prototype testbed, to be delivered at the end of Phase II, will involve software for simulating the processes of navigation, local terrain reconstruction, and image compression. It will also interface to hardware elements such as digital cameras and to a "sand model" for planetary terrain such as Mars. The innovation will be to integrate the separate functions of navigation, terrain reconstruction, and image compression by using compact, analytical descriptions of the terrain and to support the concept of "imaging in a teacup." The objectives of Phase I concern proof-of-concept issues related to using such analytical terrain descriptions for these tasks. The results of Phase I will show the feasibility of this approach, as well as a requirements specification for the testbed to be developed in Phase II. The benefits to NASA will include a testbed to explore a unified approach for more efficient and accurate navigation, terrain map updating, and image prediction and compression, resulting in more efficient use of available communication bandwidth.

Potential Commercial Applications: A potential commercial application of this type of technology is in the domain of hazardous environments. One example involves sending robots into areas denied to humans because of prohibitively high radiation levels in nuclear power plants.

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175 GSFC
91-1-08.22-2288 NAS5-31923
Short-Pulse, Compact, Tunable, Solid-State Laser
Positive Light
6116 Highway 9, Suite 2B
Felton, CA 95018
Jeremy Weston (408-335-2288)

A short pulse, compact, tunable, solid-state laser delivering pulses of 100 picosecond in the wavelength range 750 nm to 900 nm will be developed. A regenerative amplifier will be built based on the new material, chromium-doped lithium-strontium-aluminum-fluoride (Cr:LiSAF), that seems almost ideal for this application. A pulsed laser diode will provide the seed pulses for the regenerative amplifier. Phase I will evaluate the performance of the Cr:LiSAF regenerative amplifier and will assess the feasibility of seeding with a diode laser and also diode laser pumping of Cr:LiSAF. Phase II will build a two-color laser system for laser ranging.

Potential Commercial Applications: Applications exists in laser ranging and LIDAR; x-ray lithography; and high-energy physics research.

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176 GSFC
91-1-08.22-8827 NAS5-31941
High-Power, Single-Mode, Diode Lasers Operating at 1.047 Microns to 1.064 Microns
Northeast Semiconductor, Inc.
767 Warren Road
Ithaca, NY 14850
Michael S. Frost (607-257-8827)

High-power, single-mode diode lasers are of considerable interest for optical sources and solid-state lasers systems components because of their performance and reliability. Currently, these devices are in production in Japan using molecular beam epitaxy (MBE) to service the compact-disk laser market. These structures use AlGaAs and operate below 860 nm. A reasonably straightforward extension of AlGaAs quantum well materials using pseudomorphic GaInAs can be made with MBE to extend the wavelength range into the IR up to 1.07 μm. This program addresses the materials growth and fabrication technology to develop high power (100 mW) single-mode diode lasers at the wavelengths of 1.047 μm and 1.064 μm. The epitaxial structures required for these emission wavelengths require that MBE be used to exploit the extreme edge of the pseudomorphic limits of the AlGaAs/GaInAs system. The uniformity in thickness and alloy composition of MBE growth will be used in conjunction with low-cost laser fabrication methods to result in prototype quantities of hermetically sealed single-mode laser devices at the completion of Phase I. The range of applications in solid-state laser systems for NASA include frequency doubled YLF pump sources (a Phase II objective) and injection-locking sources for YAG laser systems.

Potential Commercial Applications: Application for this technology would be in YLF pump sources, injection locking sources, and low-power YAG replacements.

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177 GSFC
91-1-08.23-0800 NAS5-31928
Intelligent Receiver
Center For Remote Sensing
P.O. Box 9244
McLean, VA 22102
Suman Ganguly (703-848-0800)

A versatile state-of-the-art receiving system will be developed. The system will be able to reconfigure itself both through ground command and also through onboard intelligent processing of the radio environment. The intelligent processing unit will be able to discriminate the background information (noise, interference, etc.) from the signal of interest. This will allow an extremely low-telemetry rate and will reduce the workload of the scientists. Options for manual intervention of the interesting data will be available. Phase I will demonstrate the feasibility of the intelligent processing scheme and will deliver approaches for hardware implementation of the complete system. Actual construction and test will be performed during Phase II.

Potential Commercial Applications: Intelligent receivers will have large-scale direct commercial applications in various plasma science areas required by DOD and by university and other research and commercial entities. This scheme will be extended for efficient utilization of radio channels and will have a major impact on future radio receivers.

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09: Spacecraft Systems and Subsystems

178 GSFC
91-1-09.01-7640B NAS5-31931
Codeless, Global-Position-System, Attitude-Determination System
Ithaco, Inc.
P.O. Box 6437
Ithaca, NY 14851-6437
Stephen J. Fujiwaka (607-272-7640)

This project will define a spaceborne attitude determination system based on Global-Positioning-Satellite (GPS) signals. This specific innovation involves processing GPS signals without knowledge of the digital codes required for conventional GPS receivers, making the system immune to performance degradation resulting from the DOD policy of selective availability and anti-spoofing. Precision determination of attitude (0.05 deg) and rate (0.05 deg/sec) can be achieved at up to 10 Hz. This project addresses the need for a low-cost, low-power, and low-mass attitude determination system for use aboard small satellite missions. The systems engineering tasks are requirements definition for the onboard radio system electronic design; requirements for the satellite hardware suite; attitude-determination flight-software specifications; ground support segment definition; and planning for a ground-based proof-of-concept demonstrator to be executed under Phase II. The expected benefits to NASA are numerous, with the current trend toward development of small, low-cost, multi-mission satellites. As GPS systems become a reality, they can be expected to make traditional attitude determination systems and hardware obsolete. As an additional benefit, this system is easily adaptable for precision orbit determination.

Potential Commercial Applications: This attitude determination system will be marketed to prime contractors and other private concerns that need low-cost, precision, attitude determination. The system is also adaptable for precision orbit determination.

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179 GSFC
91-1-09.02-5500A NAS5-31884
Comprehensive, Modal-Significance, Analysis Package
Swales & Associates, Inc.
5050 Powder Mill Road
Beltsville, MD 20705
Daniel C. Leavy (301-595-5500)

As modern control concepts evolve to achieve better performance through the use of multivariable techniques and increased bandwidth, designs exhibiting interaction with structural flexibility become increasingly common. This trend has created the need to develop reliable procedures for obtaining reduced-order structural models for use in analyzing these control systems. Typical mode-sorting procedures currently employed by controls analysts only examine the behavior of the modes at the inputs and outputs of the control system without regard for the validity of the modes themselves or other considerations specific to the controller to be designed. In response, this project will develop an integrated software package that contains the analytical tools required for the engineer to obtain interactively a reduced-order model, while considering the aforementioned issues. This integrated approach will ensure that the reduced-order model captures all structural behavior of importance to the controller and will assist in identifying deficiencies in the original structural model. Once developed, this software will be valuable in many NASA and commercial applications that require analysis of structural control interaction problems.

Potential Commercial Applications: The resulting software package will be useful in both government and commercial applications requiring structural analysis as applied to controls design (e.g., aircraft, factory automation, aerospace). At the end of Phase II, the completed

software should prove marketable to the engineering community engaged in this field.

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180 JPL
91-1-09.03-1522 NAS7-1179
Interferometer Fringe and System Identification Processor
Photon Research Associates, Inc., Cambridge Division
9393 Towne Centre Drive, Suite 200
San Diego, CA 92121
Leslie Matson (617-354-1522)

The POINTS space interferometer observatory represents major advances in precision system technology, requiring coordinated operation of a number of components and subsystems with performance significantly beyond that of existing systems. A key characteristic of its performance requirement is that the mission accuracy must be far below the noise level of the measurements; and, thus, it is essential that the bias be reduced by sophisticated data processing. This processing is corrupted by interactions with the attitude control and optical metrology system and by the thermal, structural, and dynamic disturbances. The more conventional aspects of control-structure interaction are complicated here by interactions with optics and processing. The approach to dealing with these issues is an interferometer fringe and system identification processor (IFSIP). The IFSIP addresses the need to process optical fringe data from linear detector arrays observing "channelled" spectra for estimating changing instrumental biases and structural deformations, for augmenting spacecraft attitude control, and for generating reduced data that can be reprocessed on the ground. In summary, the IFSIP function is an enabling technology for POINTS on a par with the other innovations required for the system.

Potential Commercial Applications: The signal processing technique to be investigated here is generic for many types of interferometric systems and will likely find applicability with thinned-aperture and phased-array systems as well. In the scientific community, the application of IFSIP to white-light interferometry can obtain significantly improved performance. Commercial applicability to acoustic means of intrusion detection is expected to be an early goal.

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181 MSFC
91-1-09.03-2666 NAS8-39330
Autonomous, Reconfigurable, Global Positioning System and Dual Cone Scanner Navigation and Pointing Control System
Mayflower Communications Company, Inc.
80 Main Street
Reading, MA 01867
Triveni N. Upadhyay (617-942-2666)

This project addresses the need for high-performance guidance and control systems that are robust and will permit spacecraft to be maneuvered autonomously, accurately, and reliably through the atmosphere. The approach is to develop an innovative, integrated system architecture that combines the Global Positioning System (GPS) navigation and attitude determination function with the dual cone scanner (DCS) autonomous navigation function to provide an accurate, autonomous guidance, navigation, and pointing capability for spacecraft missions from low Earth orbit to geosynchronous Earth orbit. This integrated system architecture is a modified, federated filter architecture. It is reconfigurable in real-time, optimized to provide high performance for all mission phases, and exploits the synergistic features of the two navigation and pointing control sensors. Phase I will determine the performance limits of the two sensors as a function of spacecraft altitude and will develop estimates of size, power, and weight estimate for the integrated GPS-DCS system. Using demonstration hardware, Phase II will demonstrate the critical technologies identified in Phase I and will validate the integration concept. The Phase II demonstration will emulate the GPS and DCS sensor measurements by simulating the Earth, sun, and the moon.

Potential Commercial Applications: An important commercial benefit of the integrated GPS-DCS system is that it provides a practical method of determining the spacecraft state vector (position, velocity, and altitude) for a variety of missions. The cost savings due to the reduced ground tracking and mission planning is expected to more than offset the cost of procuring the proposed system.

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182 JPL
91-1-09.03-3730 NAS7-1164
Stellar Compass for Autonomous Spacecraft Guidance and Control
Intelligent Decisions, Inc.
536 Weddell Drive, Suite 2
Sunnyvale, CA 94089
Richard Kiessig (408-734-3730)

This project will investigate the applicability of the technology of the "stellar compass " to autonomous spacecraft guidance and control. The previously developed "stellar compass" is very light in weight and uses a wide field-of-view concentric lens and an integrated camera. It can determine spacecraft orientation to hundred-microradian accuracy in a few milliseconds. The software works by examining the entire currently-visible star field and generating triangles from observed stars.

Potential Commercial Applications: Combined with an accurate clock, a standardized stellar compass could be used as a lower precision substitute for Global Position-

ing Satellite (GPS) receivers as well as for a guiding device for Earth- and space-based telescopes.

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183 LaRC
91-1-09.03-6720 NAS1-19532
A More Efficient Controller
Orbital Research, Inc.
11000 Cedar Avenue, Suite 461
Cleveland, OH 44106
Yang Dong (216-791-6720)

The goal of this project is a practical, computationally efficient, robust, and adaptive real-time feedback controller for launch, landing, and maneuvering systems, satellite pointing, articulated spacecraft, and robots. A unified design and analysis method for predictive control has recently been developed. This method is based on the use of a special input-output matrix representation that provides computational savings that vary as the cube of the number of system outputs, the square of the model order, and linearly with the number of system inputs and the controller's prediction horizon. The first innovation is the conversion of these mathematical algorithms into computationally efficient software that exploits the special matrix structure leading to the computational savings required in memory and floating point operation. The Phase I project objectives involve the testing and performance evaluation of this software using computer simulations of increasing complexity, uncertainty, and noise environments. Transient performance of the controlled system and the computational speed and memory requirements of the controller software will be measured. The Phase II goal is to develop hardware for the embedded use of the software for a more efficient controller. The anticipated results are computationally efficient real-time software and embedded real-time controller.

Potential Commercial Applications: Military applications include controllers for military aircraft and spacecraft, armored vehicles, helicopters, E^2I, and submarines. Commercial uses include industrial robots and engine controls.

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184 LaRC
91-1-09.04-0540 NAS1-19543
A Superconducting, Ultra-Precision Multi-Sensor
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Timothy J. Hawkey (617-661-0540)

To meet the need for improved sensor technology for the control of large space structures, a novel, six-degree-of-freedom, superconducting, multi-sensor will be developed. The configuration features a superconducting proof-inertia suspended by magnetic forces in a rebalance configuration with tunneling-tip microscopes providing angstrom-level position information. The extremely accurate position information and reduced thermal noise at cryogenic temperatures allow very high precision linear and angular acceleration measurements to be made. Additional advantages are small size and very low power consumption. Phase I of the program will involve analytical studies, the establishment of technical feasibility, and the development of a baseline design for the superconductor, control system, electronics, sensors, and actuators. Phase II will include detailed design, fabrication, and testing of a prototype unit.

Potential Commercial Applications: A successful ultra-precision accelerometer would have many aerospace and commercial applications in inertial guidance and control units improving the performance and safety of aviation guidance systems. Series configurations could be used for gravity-gradient measurement and surveying. Ultra-precision acceleration and angular rate measurements would also be useful in vibration isolation systems for chip fabrication.

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185 LaRC
91-1-09.04-1522A NAS1-19533
Optical Processing for Structural Control of Large Spacecraft
Photon Research Associates, Inc.
1911 North Ft Myer Drive, Suite 408
Arlington, VA 22209
James C. Fraser (617-354-1522)

This project exploits the use of nonlinear optical and photonic devices to perform sensing, computing, and adaptive control of very large, flexible spacecraft subject to induced structural dynamics. Specifically, techniques and strategies would be developed to exploit the massively parallel sensing and processing potential of photo-refractive materials. Two innovations are the use of an optical novelty filter and an optical associative memory to both discriminate and resolve the dynamic modes of the spacecraft. The optical novelty filter can perform time differentiation of coherent optical images. The time constant would be varied to discriminate between the static and dynamic conditions of the structure. The associative memory can record and retrieve a large number of coherent images that would represent the dynamic mode shapes of the structure. Control signals derived from an image recognition process would then be used to drive actuators to stabilize the structure.

Potential Commercial Applications: Optical sensing and pattern recognition are critical to many industrial manufacturing processes. These include precision positioning for automated optical and electronic component assembly and inspection and measurement for process monitoring and control.

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186 LeRC
91-1-09.05-6010 NAS3-26543
Vacuum-Break Safety of Liquid Hydrogen and Helium Tanks
Cryogenic Technical Services, Inc.
3445 Penrose Pl, Suite 230
Boulder, CO 80301
Glen E. Mcintosh (303-444-6010)

The safety of vacuum-jacketed, cryogenic vessels depends on sizing the vent line and the relief devices to handle vapor generated due to high heat transfer resulting from the loss of vacuum. Vacuum jackets of hydrogen and helium tanks can experience very high air in-flow rates, especially if air condenses on the inner shell. Existing guidelines from the Compressed Gas Association do not adequately predict vapor flow under these conditions. There is little experimental heat transfer data to provide a basis for designing safe venting systems, particularly for dewars insulated with multi-layer-insulation (MLI). The focus of this project is the development of general criteria for MLI and alternate tank coatings that prevent air condensation under vacuum-break conditions. Phase II involves an experimental vacuum-break program with specially designed hydrogen and helium vessels.

Potential Commercial Applications: The MLI optimization software and test results would improve the performance and safety of cryogenic equipment, pipelines, and stationary and mobile cryogenic vessels.

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187 LeRC
91-1-09.05-8111 NAS3-26544
Cryogenic Pump for Space Applications
Barber-Nichols, Inc.
6325 West 55th Ave
Arvada, CO 80002
Kenneth E. Nichols (303-421-8111)

This project concerns a pump designed to handle liquid, vapor, or two-phase flow in a microgravity environment. The pumping element is a mixed-flow design with a large axial inducer to reduce approach velocities. This element incorporates vapor extraction in the eye to prevent vapor blockage of the pump under two-phase flow conditions. The vapor extraction is accomplished by an ejector design using a small portion of the pumped fluid for the motive energy. The pumping unit, complete with motor, can be used in-line or submerged in cryogen for mixer modes or for high-pressure rise, high-flow transfer modes. The pumping element efficiency should be 85 to 87 percent, and the high power motor, 90 percent. The unit incorporates low-loss rolling element bearings. The objective of Phase I is to test a pumping element to demonstrate performance using a two-phase fluid. Motors will be analyzed and a preliminary pump design completed. The developed pump should perform well at high efficiency with low parasitic losses. The pumps can be used for mixing or transfer where high efficiency, low-heat leak is important. The pumps will be compatible with liquid and slush hydrogen and with other cryogens.

Potential Commercial Applications: The pumping concept will find applications for circulating and transferring cryogens, as an industrial process pump handling very low NPSH or two-phase flow applications, and in seal-less pumps, a rapidly growing segment of the commercial pump business.

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188 JPL
91-1-09.06-6708 NAS7-1163
Joule-Thomson Cooler with Non-Clogging, Active Flow Control
APD Cryogenics, Inc.
1833 Vultee Street
Allentown, PA 18103
Ralph C. Longsworth (215-791-6768)

Space-based sorption compressors require high-efficiency, multistage Joule-Thomson (JT) heat exchangers with adjustable flow control that will not clog if small amounts of contaminants are present. This project investigates an innovative means of providing active flow control by using a pneumatically actuated JT valve coupled to an external control unit that also is connected to a temperature sensor at a key point in the heat exchanger. The control can regulate the size of the JT orifice to minimize compressor power input and also to clear blockages from the orifice, if they occur. Phase I includes heat exchanger design studies and fabrication and testing of a two-stage unit with N_2 contaminated with NO_2 to demonstrate the operation of the flow-control mechanism and its ability to tolerate contaminants in the gas.

Potential Commercial Applications: JT refrigerators are strong contenders in providing cryogenic cooling to a wide range of emerging cryogenic-electronic applications. A reliable active-control mechanism that is tolerant of some contaminants is vital to the success of JT cooler technology.

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189 GSFC
91-1-09.07-2221 NAS5-31940
Diaphragm Actuator for a Stirling Micro-Refrigerator
Sunpower, Inc.
6 Byard Street
Athens, OH 45701
Lyn Bowman (614-594-2221)

The innovative compressor for this closed cycle cryogenic cooling system is a silicon diaphragm actuator. This project addresses development of a compressor for a novel Stirling micro-refrigerator for cold electronics. The micro-refrigerator concept exploits the material properties, mechanical designs, tiny dimen-

sions, and batch fabrication processes of silicon micromachining technology. One preliminary design of a micro-refrigeration with a volume of one cubic centimeter predicts 0.73 W of heat lifting capacity from 100 K to 350 K with a mechanical input power of 3.2 W at 1 kHz. The inertial of the vibrating actuator is only 10^{-4}g. A critical component of the micro-refrigerator is this electromechanical actuator that drives the Stirling cycle. This project combines the high-Q mechanical properties of resonant silicon microstructures, the actuators of silicon micro-valves, and the ability of corrugated diaphragms to undergo large deflections to compress, displace, and expand the working fluid in the micro-refrigerator. Phase I will design a corrugated, silicon diaphragm actuator, capable of undergoing the required deflection, and will evaluate the capability of alternative electromechanical transduction techniques for exciting vibrations in the diaphragm. In Phase II, diaphragms will be fabricated and tested. These low-vibration, electrically powered micro-refrigerators would be ideal for providing tight closed-loop cryogenic temperature control for instruments and facilities at dispersed locations in future unmanned spacecraft.

Potential Commercial Applications: The commercialization of Stirling micro-refrigerators would increase the speed of computer processors and memories; reduce noise in radio and microwave detectors, amplifiers, and filters; reduce the bulk of infrared detection and imaging systems; and facilitate the commercialization of high-T_c superconducting electronics.

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190 GSFC
91-1-09.07-3021 NAS5-31947
Compact Heat Exchangers for Ammonia Refrigerant
DRF R&D
P.O. Box 254
Millwood, VA 22646
Daniel R. Flynn (703-837-3021)

Advanced-design, compact, low-mass heat exchangers for use with ammonia-based refrigeration systems in low- and micro-gravity environments will be developed. The specific technical objectives of Phase I are to establish design goals for ammonia refrigeration systems for low- and micro-gravity use; review unique requirements for enhanced-surface ammonia evaporators and condensers to be used in extraterrestrial applications; review prior heat exchanger designs, select performance predicting procedures, and adapt them for low- and micro-gravity situations; review alternative manufacturing technologies and select those that are most appropriate for fabrication of ammonia evaporators and condensers; collect appropriate property data for ammonia and for alternative materials to be used in fabrication of evaporators and condensers, develop a schema for rational design of practical evaporators and condensers for use in future NASA missions, and design a prototype evaporator and a prototype condenser for use in an extra-terrestrial ammonia refrigeration system. The heat exchanger design procedures that will be developed under this project will greatly enhance the ability of NASA and industry to have ammonia condensers and evaporators built that will function properly in their intended use.

Potential Commercial Applications: In addition to enabling commercial manufacture of better ammonia condensers and evaporators for use in space, the design procedures to be developed will also be very effective in promoting improved refrigeration heat exchangers for use on Earth, particularly for the ammonia refrigeration industry, in which enhanced heat exchangers are not now being used.

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191 GSFC
91-1-09.07-3221 NAS5-31926
A Liquid Cryogen Cooler for the Get Away Special Program
Applied Engineering Technologies, Limited
800 West Cummings Pk, Suite 3375
Woburn, MA 01801
James F. Maguire (617-932-3221)

This effort will perform the detailed engineering analysis of a liquid-nitrogen, flight cooler for use in a NASA-Get Away Special (GAS) experiment program. The liquid containment technology is based on a NASA-GSFC technical note, and this effort would be to perform detailed engineering analysis of a system for use as a "standard" that GAS can package for future experiments. Liquid nitrogen was chosen as the baseline fluid to produce a 80 K nominal operating temperature, although liquid neon may also be suitable, and will allow testing at approximately 25 K.

Potential Commercial Applications: This project will permit inexpensive, low-temperature testing and remote sensing in space.

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192 GSFC
91-1-09.07-8200 NAS5-31927
Utilization of Low- to Medium-Temperature Waste Heat
Chronos Research Laboratories, Inc.
4186 Sorrento Valley Boulevard, Suite H
San Diego, CA 92121
Randall B. Olsen (619-455-8200)

Recent advances in pyroelectrics have provided materials that may be useful in the direct conversion of heat into electrical energy in space systems. These materials will be manufactured at a low cost and will provide an ultra-lightweight means of generating electrical power from a system with no moving solid parts. A relatively new technology, pyroelectric conversion has the potential for high reliability and efficiency. Phase I will measure the useful lifetime of pyroelectric conver-

sion material with a newly fabricated, experimental apparatus. The properties of this advanced material will be followed for extended time periods since it is subject to the thermal and electrical cycling conditions that will exist in pyroelectric energy converters.

Potential Commercial Applications: In addition to space power systems, pyroelectric converters are expected to convert low temperature heat economically into electrical energy in terrestrial systems with payback times of less than 2 years.

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193 MSFC
91-1-09.08-1856 NAS8-39321
Cryocooler for Direct Circulation of Refrigerant to Instruments, Shields, and Dewars
General Pneumatics Corporation, Western Research
7662 East Gray Road, Suite 107
Scottsdale, AZ 85260-6910
Woody Ellison (602-998-1856)

A multistage Stirling cryocooler will be developed to circulate coolant directly to spaceborne instruments, shields, and storage dewars without need for an intermediate heat exchanger, separate cryogenic pump, or for any hazardous fluid. The proposed refrigerator has two expansion states producing refrigeration at 90 K and 56 K. Later development is anticipated for the addition of a third stage operating at 20 K. Simplified, single-stage versions could also be derived for more utilitarian cooling needs over the range of 80 K to 270 K. The machine will incorporate several innovative features to achieve an especially compact arrangement with high thermodynamic efficiency and long-life operation. One innovative feature is the use of the controlled ingress and egress of the helium-working fluid itself from within the refrigerator to the external coolant transfer loop to directly convey refrigeration to the point of need. Also incorporated is a new concept for precisely tailored, high-effectiveness, thermal-composite heat exchangers. The drive mechanism provides straight-line piston motion to minimize side forces, wear, and vibration and to facilitate incorporation of positive seals to preclude contamination of the working fluid.

Potential Commercial Applications: This cryocooler would apply in the long-term cryogenic cooling of spaceborne instruments and stored cryogens and in applications such as superconductors and supercooled computers, magnetic resonance imagers in medical research, materials research, and development of freon-free refrigeration.

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194 MSFC
91-1-09.08-2991 NAS8-39313
Improved Stirling-Cycle Technology for Zero-Gravity Spacecraft Refrigeration Systems
Dean Applied Technology Company
6720 Steeplechase Drive
Huntsville, AL 35806
W.G. Dean (205-830-2991)

This project seeks to improve Stirling cycle refrigeration technology by replacing the conventional expander with a pulse tube, changing to a Bellows compressor, and optimizing the design to work in the temperature range required for refrigerator-freezers. This concept is applicable to zero-G spacecraft refrigeration because it solves numerous problems associated with the two-phase, vapor-liquid, concept currently being used. These problems include two-phase fluid transfer in zero-G, boiling and condensing heat transfer in zero-G, and potential damage due to liquid being inside the compressor at startup. Since it uses inert helium gas, it eliminates potential hazards from CFC refrigerants that are inherent in other systems. The objective of Phase I is to determine the feasibility of this concept through analyses, trade-off studies, preliminary design, and comparisons with other systems. Benefits to NASA include refrigerator-freezers for support of experiments and food storage for spaceflight programs including the Space Lab, Space Station Freedom, and Manned Lunar/Mars Initiative Programs.

Potential Commercial Applications: This effort has a direct and immediate commercial application as a cost-effective, alternative refrigeration concept for commercial and domestic refrigerator-freezers and automotive, domestic and commercial air conditioning units that use inert helium gas rather than CFC refrigerants.

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195 JSC
91-1-09.08-6551B NAS9-18674
Ultra-Lightweight Unfurlable Radiator
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
Nelson J. Gernert (717-569-6551)

Lunar and Mars manned bases being considered by NASA will need to reject in excess of 100 kw of thermal power. Current state-of-the-art aluminum-ammonia, heat-pipe space radiator technology being developed for Space Station Freedom is too heavy and voluminous to be used for these future space missions. Accordingly there is a need for a revolutionary advanced space radiator system. This project outlines an effort to satisfy that need through the development of a collapsible, multiple-heat-pipe radiating system that is extremely light weight ($0.43 \leq Kg/m^2$). This system is about sixteen times lighter than a conventional radiator's weight of 7 Kg/m^2. The feature of collapsibility will allow the system to be compactly rolled or folded, easily stowed for transit

to space, and unfurled to present a large radiating surface. The radiator panel will be fabricated from a 0.006-inch thick heat-sealable, extremely flexible polymer and metal film laminate that is divided into several independent heat-pipe cells. These multiple cells add redundancy to the system, which in turn yields increased reliability. The technical feasibility of the proposed innovation will be demonstrated through the design, fabrication, and test of a proof-of-concept polymer and metal-film laminate, heat-pipe radiator panel.

Potential Commercial Applications: The applications of a reduced-weight heat rejection system will extend to NASA, military, and commercial spacecraft, as well as for use on future lunar and planetary bases. A lightweight heat pipe radiator may have significant economic benefits due to the reduced payload weight and volume.

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196 JSC
91-1-09.08-8200A NAS9-18702
Nitinol Refrigerator
Chronos Research Laboratories, Inc.
4186 Sorrento Valley Boulevard, Suite H
San Diego, CA 92121
Randall B. Olsen (619-455-8200)

An advanced refrigerator and/or heat pump based on the elasto-caloric effect of Nitinol is proposed. Nitinol (Nickel Titanium alloy developed at Naval Ordnance Laboratory) has one of most energetic solid-state phase transitions known. Nitinol has been widely studied for prime-mover heat engines, but not for refrigeration. The Nitinol technology offers safety, high efficiency, high reliability, long life and no chlorofluorocarbon (CFC) release problems. The objective of Phase I is to demonstrate refrigeration and heat pumping using Nitinol as the thermodynamically active medium and to design and to estimate the performance of the Phase II Nitinol refrigerator.

Potential Commercial Applications: In addition to refrigeration, heat pumping, and air conditioning systems, Nitinol materials are expected to convert low-temperature industrial waste heat into electrical energy economically with payback time of less than two years.

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197 GSFC
91-1-09.09-1791 NAS5-31946
Real-Time Monitor of Particle Depositions on Surfaces
EOS Technologies, Inc.
606 Wilshire Boulevard, Suite 700
Santa Monica, CA 90401
Robert J. Champetier (310-458-1791)

This project is a passive device that can, on command, sense and measure the amount of dust and other contamination accumulated on its sensitive surface. The principle used is to illuminate the surface at grading incidence with light from a diode laser. The surface consists of a glass plate exposed to the environment of interest. Discrete particles collected on the plate scatter some of the light, and a portion of the scattered power is detected by a large area silicon sensor beneath the plate. Additional diode lasers and features make it possible to measure separately the scatter caused by dust, molecular films, and erosion and to do this while exposed to the sun. The initial concept has a smooth, washable, exposed surface with no protrusions and a device package about the size of a small, thick book. The basic principles have been demonstrated, and the sensitivity should extend from MIL-STD-1246 levels below 100 to above 700.

Potential Commercial Applications: There are two types of applications. One is for devices geared for spacecraft use with emphasis on low weight and ruggedness. The other is for routine use in vacuum test or production systems with emphasis on convenience, software interface, standardized design, and low cost.

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198 MSFC
91-1-09.10-6468 NAS8-39305
Modeling Debris Cloud Formation and Hydrodynamics
Alme & Associates
6219 Bright Plume Drive
Columbia, MD 21044
Marvin L. Alme (301-997-6468)

This project will incorporate a state-of-the-art strength model (Steinberg-Guinan) and a realistic material properties library (LLNL KOVEC) into a smooth particle hydrodynamics (SPH) code. SPH is a new hydrodynamics method invented in the astrophysical community and has only been successfully applied to gas dynamics problems. The physical models needed to simulate hypervelocity impact with an existing SPH code and to simulate debris cloud formation and stagnation will be combined. SPH promises to revolutionize projectile fragmentation calculations. Since the algorithm is based on a particle representation with no mesh, resolution of fragments of the size of the simulation particles is achieved. Particle splitting and variable weight schema are used to achieve subparticle resolution. This innovation will permit physically based simulation of the stagnation of debris clouds, thus increasing the reliability of simulations of the protection and penetration of critical space structure components. Phase I will focus on demonstrating feasibility in dimensions, but, because SPH is inherently three-dimensional, this also addresses the requirement to model impacts by nonspherical debris particles.

Potential Commercial Applications: The expected NASA application is to study advanced shield design. The firm does not expect any commercial applications.

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199 JSC
91-1-09.10-8500B NAS9-18680
Spacecraft, Hypervelocity-Impact-Protection, Ceramic-Based Shielding
Interferometrics, Inc.
8150 Leesburg Pike, Suite 1400
Vienna, VA 22182-2799
Joan F. Cartier (703-790-8500)

The goal of this project is to show the effectiveness of improved spacecraft shielding that can be realized through the transfer of ceramic and advanced armor technology from military research and development programs. A material selection, design, and optimization program will result in a significant improvement in the mass efficiency, effectiveness, and cost benefits of spacecraft shielding. Measures of effectiveness will include optimized dispersion of projectile momentum and energy, and a tolerance for extreme environmental conditions during launch and in orbit. Additionally, shielding optimization models developed in this research will allow user agencies to modify spacecraft shield designs to meet evolving requirements. Cost and weight trade-off and benefit models will ensure that shielding remains within realistic constraints.

Potential Commercial Applications: This project represents an approach to increasing satellite protection with a clear appreciation of cost and weight constraints. Lightweight armors designed through this program may also find use in ground-based applications.

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200 JSC
91-1-09.11-6000 NAS9-18678
Silicon-Based, Full-Color, Flat-Panel Display
Spire Corporation
One Patriots Pk
Bedford, MA 01730-2396
Fereydoon Namavar (617-275-6000)

This project will lead to fabrication of full-color, flat-panel displays entirely on silicon substrates. This may be feasible by recent advancements in fabricating bright, visible light-emitting silicon quantum wires. The firm has produced photoluminescent (PL) silicon quantum wires with red, orange, yellow, green, and blue emission by electrochemically etching bulk silicon under different conditions. Although electroluminesence (EL) of these wires has not yet been demonstrated, we have observed emission similar to PL results from the samples immersed in an H_20: NaCl electrolyte with an applied electric field. In Phase I, the firm will fabricate silicon quantum wire test structures and demonstrate EL performance. Based on the results, multipixel monochrome silicon EL displays will be fabricated, and fabrication of full-color silicon EL display panels will be explored in Phase II. The above-mentioned findings, combined with mature silicon technology, offer a rare opportunity for a major advance in flat-panel displays. This new approach will make it possible to integrate monolithically the light-emitting elements of a panel display and the associated electronics on the same substrate. Such a development would result in significant reduction of fabrication steps and therefore cost. In addition, this technique will circumvent problems associated with flat-panel displays using dissimilar materials, such a zinc-sulfide-on-glass, which require chip-on-glass technology or an external driver circuit.

Potential Commercial Applications: This project could lead to low-cost, high-efficiency, silicon-based display panels with integrated driver circuits. These panels will have immediate applications in a broad range of technologies, from aerospace to medical; later applications could include high-definition television.

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201 JSC
91-1-09.12-8414A NAS9-18677
Robotic Systems and Automation for Space Applications
Ellery Systems, Inc.
5600 Arapahoe Ave
Boulder, CO 80303
Peter G. Ossorio (303-443-8414)

Descriptive psychology (DP) provides an explicit, detailed, and extensively tested conceptual structure that applies equally to biological and nonbiological individuals. Therefore, it is potentially a foundation-level theory for robotics. This project aims to demonstrate the applicability of the DP framework to an existing robotic system designed for space mission activities. It also plans to use this framework to design increased functionality into the selected robotic system and to delineate a development path for making existing systems more functional and more human-like.

Potential Commercial Applications: Potential applications are remote and hazardous manufacturing; ocean exploration; exploration, exploitation of and working in hazardous environments; mining; construction in hazardous environments; robotic manufacturing; commercial robotics; and materials production in hazardous environments.

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202 JSC
91-1-09.12-8414B NAS9-18687
An Expert System for Planning, Design, and Management Support
Ellery Systems, Inc.
5600 Arapahoe Ave
Boulder, CO 80303
Peter G. Ossorio (303-443-8414)

A state-of-affairs (SA) system provides what amounts to a canonical form for representing real-world phenomena (configurations of objects, processes, events, and states of affairs), either actual or hypothetical. In contrast, representational forms in science, engineering, administration, and ordinary discourse are of varied and unknown commensurability. Success in the comprehensive information systems applications of an SA system depends on success in replacing or implementing other forms of representation with the canonical form, or extending the implementation capabilities of an SA information system to integrate other forms of representation. Accordingly, the aim of this effort is to establish the representational needs in two or three areas (as feasible) such as preliminary planning, requirements generations, and design knowledge capture, and for each type of representation, to either show how it can be accomplished as a SA representation, or show how it could be implemented in a SA-based information system.

Potential Commercial Applications: Applications could include large-scale project management, project requirements gathering and planning, advanced aircraft manufacturing and operation, spacecraft manufacturing and operation, nuclear energy plant production and operation, large-scale construction project management, manufacturing operations, and complex software development and requirements planning.

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203 GSFC
91-1-09.13-0604 NAS5-31886
Satellite-Guided Parafoil Recovery System for Balloon Payloads
Vertigo, Inc.
P.O. Box 117
Lake Elsinore, CA 92531
Glen Brown (714-674-0604)

The objective of this project is to develop, demonstrate, and deliver a balloon payload recovery system capable of entirely autonomous operation to a low-energy landing. The two most significant innovations of this project are in guidance and control and reduced actuator power. GPS-based guidance software and interface hardware will be developed to control a parafoil vehicle to a precision approach and landing. Control of parafoils by current methods increases as $(mass)^{3/2}$, resulting in very high power for large systems. An innovation is expected to reduce significantly actuator power requirements for large parafoils. The Phase I effort includes analysis, preliminary design tasks, and subscale testing. The results of this effort will predict performance and supply a system description with sufficient detail to assess feasibility.

Potential Commercial Applications: This system could apply to the recovery of suborbital commercial microgravity payloads. An airdrop version could deliver equipment to hazardous or inaccessible areas such as forest fires or toxic spill incidents. The actuator will be of benefit to NASA in future maneuvering recovery systems for heavy payloads.

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10: Space Power

204 LeRC
91-1-10.01-6551A NAS3-26325
Sulfur Heat Pipe for 600 Kelvin, Space Heat-Rejection System
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
John H. Rosenfeld (717-569-6551)

There is a need for a heat pipe working fluid in the 600 K temperature range for use in low-mass, heat-rejection radiators for future spacecraft that may include the SP-100 nuclear reactor space power system. No suitable fluids have been identified. Sulfur had been rejected for heat pipe service because of excessive viscosity. The addition of 3-10 percent iodine can reduce the viscosity by three orders of magnitude to a useful level. This project's objective is the characterization of sulfur-iodine mixtures as heat pipe fluids. Specific measurements of thermal conductivity and compatibility with wall and wick materials will be conducted in order to qualify these materials. Phase II will result in development of full-scale radiator heat pipes using sulfur-iodine working fluids.

Potential Commercial Applications: A significant non-governmental market exists in high-temperature, heat-recovery heat exchangers.

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205 LeRC
91-1-10.01-6551B NAS3-26324
Insoluble Coatings for Stirling-Engine, Heat-Pipe Condenser Surfaces
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
Peter M. Dussinger (717-569-6551)

Dish Stirling systems are one of the most promising applications of the Stirling engine technology. Solar energy is concentrated by a parabolic reflector and is

directed to a liquid-metal, heat-pipe receiver that delivers concentrated solar energy at a uniform temperature to the Stirling engine. One issue raised in the design phase of heat-pipe receivers was the solubility of the Stirling engine heater-head materials in the liquid metal working fluid, typically sodium, potassium, or NaK. Phase I evaluates candidate coating materials, applied to nickel heater-head materials, that are practically insoluble in sodium, potassium, or NaK. Recent developments in coatings and coating application technology, developed for wear and surface damage resistance in liquid-metal, nuclear reactor systems, are also demonstrating corrosion resistance. The rate of corrosion is two orders of magnitude less than nickel-based superalloys. The majority of the solubility data in the literature was collected in pumped loop environments. To establish the reliability of Stirling engine receivers and heater heads, a testing program to determine corrosion rates in heat pipes operating at simulated Stirling engine conditions with insoluble coatings will be developed.

Potential Commercial Applications: This technology can be incorporated into terrestrial Stirling thermal power systems, space Stirling power systems, and ultimately will be used for any long-life, high-reliability, liquid-metal heat pipe applications.

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206 LeRC
91-1-10.02-9944 NAS3-26595
Flexible, Lightweight, Copper Indium Diselenide/Cadmium Sulfide, Monolithic, Solar Cells Interconnected in a Roll-to-Roll Process

Iowa Thin Film Technologies, Inc.
Isis ISU Research Park, Suite 607
Ames, IA 50010
Derrick P. Grimmer (515-296-9944)

Space power systems need flexible, lightweight solar arrays with specific performance in W/kg exceeding baseline thin-Si design. An innovative copper indium diselenide-cadmium sulfide (CIS-CdS) solar module in which the devices are fabricated on thin metal foil using continuous roll-to-roll processes will be developed. The coated foil is then continuously cut and laminated to a polymer (polyimide) backing, and the cells are monolithically interconnected in a roll-to-roll process. This will be a great improvement over current technologies in both power-to-weight ratio and manufacturing cost. The device structure consists of a CIS layer formed by the thermal interdiffusion, annealing, and crystallization of Cu, In, and Se layers deposited onto a molybdenum-coated 0.0005" thick stainless steel or nickel foil. This is followed by the deposition of a CdS window layer to form a heterojunction device. Eventually, the device structure will be optimized for the AM0 spectrum by using Cu-In-Ga-Se graded gap structures. Phase I will perform proof-of-concept studies on high-volume manufacturing techniques required for large-area deployment of space solar arrays.

Potential Commercial Applications: Flexible lightweight CIS-CdS solar arrays would have applications in space for high earth orbit and for lunar and Mars surface power systems.

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207 JPL
91-1-10.03-3800 NAS7-1175
Zero-Gravity Condensate-Management Device for AMTEC Cells

Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Christopher J. Crowley (603-643-3800)

The goal of this project is to create an innovative condenser component which will enable technology for alkali-metal thermal-to-electric conversion (AMTEC). AMTEC devices are strong candidates for space power applications, such as radioisotope generators, because of high conversion efficiency, low mass, modularity, redundancy, and reliability (absence of moving parts). This novel condenser component would enable the AMTEC technology to achieve two critical goals: microgravity fluid management and a conversion efficiency greater than 20 percent. Conversion efficiency is presently less than ten percent in laboratory tests without this condenser. With this condenser component, it is expected that the efficiency of AMTEC power conversion will exceed 20 percent and, with improved electrode technology, possibly approach 25 to 30 percent. This project will experimentally demonstrate the feasibility of the capillary fluid management with this innovative condenser design through separate effects tests. Phase II will complete the condenser development by building a working AMTEC cell (including the condenser) and demonstrating its operation--fluid management, high conversion management and high conversion efficiency--at normal gravity.

Potential Commercial Applications: AMTEC power conversion systems coupled with radioisotope heat will provide a power unit one-fourth to one-half as massive as alternative approaches, thereby saving millions of dollars in launch costs. Applications of interest include NASA space probes and rovers, Air Force and SDIO space missions, and solar-powered or combustion systems for Earth applications.

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208 LaRC
91-1-10.04-6696 NAS1-19527
Aluminum-Gallium-Arsenide, Photovoltaic, Space-Laser Energy Converters
Kopin Corporation
695 Myles Standish Boulevard
Taunton, MA 02780
Mark B. Spitzer (508-824-6696)

This project addresses the development of a space-based, laser energy converter for power transmission. The unique and innovative aspects include increasing the operating range of the converter to high power densities, on the order of 100 watts/cm^2, by using a series-connected array approach to reduce series resistance. A substrate removal approach will reduce thermal impedance between the active semiconductor layer and heat sink. To make this improvement possible, direct gap materials must be used. Phase I will consist of work to demonstrate the feasibility of this approach. In Phase II, a prototype device will be demonstrated.

Potential Commercial Applications: Applications are in the conversion of space-based laser light to electrical energy and in conversion of light from an optical fiber into electrical energy over a broad energy density range. Additional applications include power transmission via tamper-resistant and EMI-resistant optical cables.

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209 JPL
91-1-10.05-6696 NAS7-1187
Hardened, Thin-Film Aluminum-Galium-Arsenide Solar Cells with Specific Power Over 700 Watts/Kilogram
Kopin Corporation
695 Myles Standish Boulevard
Taunton, MA 02780
Ronald P. Gale (508-824-6696)

There is currently a need for space power systems which are both lightweight and able to survive the hostile radiation environment of space orbit. The objective of this project is to develop a large-area, thin-film AlGaAs solar cell that is over 20 percent efficient (one-sun, AM0 @ 28°C) with a specific power over 700 W/kg with a 4-mil coverglass. By using AlGaAs as the absorber material, the end-of-life efficiency will be improved over that of GaAs cells. Phase I will investigate the growth and fabrication of thin-film AlGaAs solar cells with a bandgap of 1.5 eV. The material will be grown by organometallic chemical vapor deposition, and solar cell structures will be deposited on bulk substrates. Bulk cells will be fabricated and tested with comparisons made to predicted cell performance from theoretical models. Thin-film cell structures will then be fabricated to demonstrate the feasibility of this approach. The Phase I goal is the delivery of AlGaAs cells with specific power of 700 W/kg, an area of 8 cm^3, and a beginning-of-life efficiency of 19 percent. Phase II will include radiation testing and end-of-life optimization of the cells, increasing the cell area to 24 cm^2, and integration of the cell into state-of-the-art array technologies.

Potential Commercial Applications: This product will extend the lifetime of many satellites, allow for payload capacity, and will be applicable in both military and commercial satellites and planetary missions.

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210 LeRC
91-1-10.06-7270 NAS3-26329
A Regenerative, Solid-Ionomer, Alkaline, Membrane Fuel Cell
Giner, Inc.
14 Spring Street
Waltham, MA 02254-9147
John A. Lisek (617-899-7270)

An efficient, lightweight, compact electrochemical storage system is important to the success of many future NASA missions. Regenerative fuel cell systems have a high potential, but with the currently available technologies, a single-unit regenerative fuel cell is not practical. An advanced single-unit regenerative fuel cell (RFC) that features a solid-ionomer alkaline membrane (SIAM) like the electrolyte, in conjunction with novel bifunctional oxygen catalysts and electrode structures, will be evaluated. This RFC is expected to combine the best features of alkaline electrolyte and proton exchange membrane (PEM) technology. The anticipated advantages of the SIAMRFC include: improved system efficiency, increased stack lifetime, significant weight, volume, and cost reductions, and improved reliability. The program includes development and testing in both fuel cell and electrolysis modes of modified SIAMs and bifunctional oxygen catalyst-electrode structures in a single-unit RFC. A goal is to obtain projected performance in both modes comparable or superior to that of the corresponding dedicated alkaline cell.

Potential Commercial Applications: Some potential commercial applications for the SIAM include power sources for transportation, peak power shaving, and energy storage in conjunction with nuclear, solar, wind, tide, or river power.

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211 JPL
91-1-10.07-9450A NAS7-1162
Lithium Ion Batteries with Improved Carbon Anodes
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
K.M. Abraham (617-769-9450)

This project is intended to provide a safe alternative to secondary lithium cells that use lithium metal as the anode by improving the performance of carbon anodes for cells having the configuration C//liquid electrolyte//$LiNiO_2$. Controlled modification of the surface

groups on carbons with graphite-like structure will be related to electrochemical performance. Such modification is intended to maximize cell capacity and limit parasitic side reactions between the anode and the electrolyte.

Potential Commercial Applications: Commercial applications for a practical cell are computers, televisions, camcorders, cameras, hand-held tools, and computer memory backup.

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212 JSC
91-1-10.08-1140 NAS9-18705
Intrinsically Safe, Rechargeable Magnesium Batteries for Space Station Freedom
Covalent Associates, Inc.
52 Dragon Ct
Woburn, MA 01801
Victor R. Koch (617-938-1140)

Safe, high-energy-density, rechargeable batteries are required for a wide variety of applications on board Space Station Freedom as well as for EVA excursions around it. Lithium and sodium-based technologies offer high specific energies, but safety and reliability are problematic, especially in a closed, manned environment. Preliminary work has shown that the intrinsically safe magnesium electrode can be reversibly cycled against a high-energy, transition-metal-oxide, solid cathode. This cell manifested little polarization in a highly conductive non-aqueous electrolyte. Phase I will evaluate three high-energy-density cathode materials against magnesium. These materials afford theoretical specific energy densities approaching 1000 Wh/kg and practical energy densities of 200 Wh/kg, about six times higher than state-of-the-art NiCd cells.

Potential Commercial Applications: Safe, reliable, high-energy-density, rechargeable Mg batteries will find use in satellites, deep space probes, portable communications equipment, and other consumer products currently employing NiCd batteries.

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213 JSC
91-1-10.08-9450 NAS9-18708
Rechargeable, Sealed Zinc-Oxygen Cells
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Gerhard L. Holleck (617-769-9450)

NASA requires rechargeable electrical energy storage for manned applications. Batteries need to be safe, compact, and of high specific energy. This will be achieved by development of hermetically sealed zinc-oxygen cells with bifunctional-oxide-catalyzed cathodes and long-cycle-life zinc anodes. Phase I includes design, tradeoff studies, prototype fabrication, and testing of cells to demonstrate system feasibility and establish component and design parameters for optimization during Phase II. After development, it is expected that a practical rechargeable Zn-O_2 cell of approximately D-size will have a specific energy of 120 to 150 Wh/kg, an energy density of 150 to 250 Wh/l, and a life exceeding 200 cycles. This represents a three- to four-fold increase in specific energy over NiCd cells. Sealed rechargeable Zn-0_2 batteries would be suitable power supplies for cameras, tools, scientific instrumentation, and life support backpacks.

Potential Commercial Applications: The rapidly expanding variety of portable electronic and electromechanical products places a high demand on light-weight rechargeable batteries. Sealed Zn-0_2 will be particularly useful for weight-sensitive applications such as commercial and military space missions, for hand-held tools and devices, and for electric automobiles.

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214 JSC
91-1-10.08-9450A NAS9-18676
A Rechargeable Solid-State Battery
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
K.M. Abraham (617-769-9450)

A rechargeable solid-state battery for powering equipment used in manned space activities will be developed with a mid-discharge voltage of about 3V, a specific energy of greater than 120 Wh/kg, and a volumetric energy density exceeding 250 Wh/l. The battery will be safe and is expected to have a discharge rate and cycle-life capabilities surpassing the needs of the application. Solid-state construction based on electrode and electrolyte laminates will allow facile scale-up of the battery in a variety of sizes and shapes.

Potential Commercial Applications: Potential commercial applications of rechargeable solid-state batteries include portable radios, televisions, camcorders, computers, telephones, hand-held tools, and ultimately electric vehicles.

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215 MSFC
91-1-10.09-6000 NAS8-39342
High-Density, Long-Life, Radionuclide, Voltaic Energy Source
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Charles C. Blatchley (617-275-6000)

This project will develop a radioisotope-powered, indium-phosphide voltaic cell that can achieve energy densities over ten thousand times greater than that of the best chemical batteries. The power attained in past

attempts to develop radioisotope-powered voltaic cells (beta-voltaic cells) was severely limited because of radiation damage to the silicon semiconductor material used in them. The marked radiation damage resistance and annealing properties of indium phosphide remove this fundamental limitation and permit consideration of high-energy beta and alpha emitters resulting in a cell with almost no detectable external radiation. Efficiencies are expected to be twice that of radionuclide-powered thermoelectric generators.

Potential Commercial Applications: High-efficiency, maximum energy density, and long operating life promise superiority over other compact power technologies, especially for space applications, cardiac pacemakers, printed-circuit memory maintenance, and remote instrumentation. These devices could replace chemical batteries in many settings.

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216 MSFC
91-1-10.10-3633 NAS8-39343
A Distributed, Autonomous, Coordination Architecture for Functionally Redundant Intelligent Systems
Symbiotics, Inc.
725 Concord Avenue
Cambridge, MA 02138
Richard M. Adler (617-876-3635)

Automation is critical to minimize human requirements for managing operations of complex distributed networks such as the power management system for Space Station Freedom. Intelligent systems are successfully automating individual control tasks such as fault diagnosis and configuration management. However, further increases in automation will require the development of autonomous control models that coordinate heterogeneous, distributed operations support applications to work together cooperatively. Functionally redundant systems represent an interesting problem. These systems provide overlapping, complementary, or duplicate problem-solving capabilities, such as rule-based, model-based, and neural network technologies, for fault diagnosis. Functionally redundant systems offer opportunities for knowledge synthesis, hypothesis confirmation, and fault-tolerant behavior. This effort will develop innovative group-based models and neural network technologies for fault diagnosis. Functionally redundant systems offer opportunities for knowledge synthesis, hypothesis confirmation, and fault-tolerant behavior. This effort will develop innovative group-based models for autonomous coordination to achieve these synergistic benefits. Specific goals will be to investigate generalized interaction models for competitive, consensual, cooperative, and duplicate activities; and to design an autonomous control architecture that unifies and applies these interaction models to coordinate functionally redundant, heterogeneous, distributed intelligent systems. These advanced control capabilities will enable NASA to increase automation and safety in both space-based systems and ground control centers.

Potential Commercial Applications: Intelligent distributed control architectures are broadly applicable to operations and decision support for complex communication, computer, power and transportation networks, and for process control in manufacturing and office automation domains.

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217 LeRC
91-1-10.10-5709 NAS3-26594
A 350-Degree-Centigrade, 6H-Silicon-Carbide Thyristor
Cree Research, Inc.
2810 Meridian Parkway, Suite 176
Durham, NC 27713
John A. Edmond (919-361-5709)

Silicon carbide possesses a unique combination of properties, not available from other more common semiconductors, that allow it to operate in certain severe environments. These properties include a wide band-gap, a high melting point, high breakdown electric field, and high thermal conductivity. It is being examined for employment in temperature-, radiation- and EMP-resistant electronics, high frequency/high power devices, as well as blue LEDs and UV photo-detectors. Although the excellent properties of SiC have been known since the 1950s, its development as a semiconductor has been severely limited because of the difficulty in growing high-quality, large-area, single crystalline material from which to fabricate devices. The development of a process for growing single crystal boules of 6H-SiC at North Carolina State University, with further improvement in process control and crystal size and quality, has lead to rapid advances in SiC device development and performance. The company produces the world's only commercially viable, blue-light emitting diode (LED) using 1-inch-diameter wafers produced from these boules and is in the process of scaling up to 1.375 inch production. The firm has developed a high-efficiency UV detector and a high-voltage, high-speed rectifier and demonstrated a complete range of field-effect transistors (MOSFITs, MESFETs, and JFETs) in SiC. All of them can operate at temperatures in excess of 350°C. Many military and commercial applications need solid-state components that can operate at high temperature for use in power conditioning and control. Phase I will demonstrate a 6H-SiC n-p-n-p thyristor as a basis for development in Phase II of a power thyristor that can operate continuously at 350°C.

Potential Commercial Applications: Development of a high-temperature silicon-carbide thyristor will provide system designers one of the fundamental components needed for power conditioning and control circuitry in

next generation spacecraft, aircraft, and marine, nuclear, and industrial systems.

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11: Space Propulsion

218 MSFC
91-1-11.01-0333A NAS8-39337
An Interactive Tool for Discrete Phase Analysis in Two-Phase Flows
Scientific Research Associates, Inc.
P.O. Box 1058
Glastonbury, CT 06033
Jayant S. Sabnis (203-659-0333)

Multi-phase flow effects in liquid and solid propulsion systems have profound impacts on performance and durability. For example, the dynamics of aluminum oxide particulates in solid rocket motors affect the slag accumulation, thereby affecting the performance. Particulate impingement on the motor casing and nozzle affects the durability via its influence on the thermal load on the insulator. The effect of the discrete phase on performance and durability can be significant even when the concentration of the discrete phase is too low to alter the continuous-phase flow-field in a significant manner. An innovative workstation-based analysis tool that can be used by analysts and designers to assess the discrete-phase effects during the development and testing of rocket propulsion systems will be developed. The workstation-based software will use Lagrangian analysis for the discrete-phase motion and will include a graphical interface allowing the user to change the relevant parameters to conduct parametric studies interactively.

Potential Commercial Applications: The analysis of discrete-phase effects applies to a variety of applications that involve two-phase flows, for example liquid and solid rocket propulsion systems, sand/particle separators, and fans and compressors operating in a dusty environment.

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219 MSFC
91-1-11.01-8051 NAS8-39304
A Generalized Computational Fluid Dynamics Package for All Mach Numbers
Aerosoft, Inc.
P.O. Box 11334
Blacksburg, VA 24062-1334
David C. Slack (703-951-8051)

This project's goal is a complete computational fluid dynamics (CFD) package capable of efficiently and accurately solving a wide range of complex three-dimensional problems. The package will combine current state-of-the-art technology in grid generation, CFD flow solvers, and workstation graphics. The first part of the investigation will involve improving the robustness and computational efficiency of the existing CFD code, GASP, for low-Mach-number flows. After achieving this goal, a graphical interface will be developed to facilitate grid generation and preparation of input to complex CFD applications, the monitoring of the solution process while the CFD application is running, and post-processing of results. The front-end application will make use of the FAST post-processing libraries as the graphical interface. It will reduce the total real cost required to perform numerical simulations of complex three-dimensional systems such as advanced military fighters, a high-speed civil transport, solid and liquid rockets, and other internal combustion engines.

Potential Commercial Applications: Analysis and design of high-speed aircraft and engine components will benefit from this package. Commercial applications include the design of trans-atmospheric vehicles, advanced concept fighters, inlets, combustors, and supersonic aircraft.

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220 MSFC
91-1-11.02-2008 NAS8-39338
Conjugate Heat-Transfer Analysis for Solid Rocket Motors
Seca, Inc.
3311 Bob Wallace Avenue, Suite 203
Huntsville, AL 35805
Jon A. Freeman (205-534-2008)

Complex heat-transfer processes occur in a solid rocket motor between the particle-laden exhaust gases, ablative nozzle inserts and liners, case insulation, and metallic walls of the motor. These are critical to the thermal design, the base heating and signature of the motor and the launch-stand heating caused by the motor. A computational fluid dynamics analysis of these conjugate heat-transfer processes will be developed as a thermal design tool for solid rocket motors. The high particle loading of the exhaust gases and the ablative behavior of the thermal protection system require major material evaluations and new code development. This design tool constitutes an analytical technique for thermal design of solid-rocket-motor nozzles, including the critical throat region, and all insulation materials. If the motor cases and insulation are made of advanced composite materials, the analysis will indicate the critical thermal properties that must be experimentally determined to effect a valid thermal design.

Potential Commercial Applications: Applications would be within NASA, DOD, and/or their prime contractors for use in analyzing advanced and solid propellant motors.

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221 MSFC
91-1-11.02-4747 NAS8-39322
TRASYS CAD Package for Radiation Model Development
Huntsville Sciences Corporation
150 West Park Loop, Suite 102
Huntsville, AL 35806
James V. Mcanally (205-830-4747)

This project is a two-fold innovation. The TRASYS Radiation Program will be converted to a Silicon Graphics IRIS engineering workstation, and an accompanying CAD software package will be developed to interactively construct TRASYS surface radiation models. The newly created version of TRASYS, including the CAD package, will be simple and easy to use for interactively constructing multi-surface radiation models. An existing CAD package (CAD/SINDA) and a finite-element unstructured grid generator (GEN/SINDA) used in developing thermal structure models for SINDA will be the starting points for Phase I. With minimum changes, CAD/SINDA can be used to develop the surface geometry for radiation models. After the surface geometry for the radiation model has been developed with the CAD program, the user presses the IRIS command key, which instructs the CAD program to create an output file. This file contains sufficient geometric data to construct a finite-element computational grid network for the model surface. GEN/SINDA currently computes structural grids for SINDA. GEN/SINDA will be modified in Phase I to produce surface grid networks only. Color graphic plot software that is currently available in both CAD/SINDA and GEN/SINDA will display the surface mesh at various points during TRASYS model development. When satisfied with the surface grid network, the user gives another key stroke command which instructs the program to output a file containing the coordinates of the points and the line and surface radiation definitions in the proper format for TRASYS input. TRASYS then computes surface radiation conductors which can then be passed directly to SINDA to compute the structural temperature response.

Potential Commercial Applications: Commercial applications of this type of technology are limited. However, those who currently use the TRASYS in the commercial arena would have a definite need for this technology. Prime contractors of NASA's major programs that require radiation analyses in the design of hardware could effectively use this technology.

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222 MSFC
91-1-11.02-8581 NAS8-39335
Semi-Rigid, Tailorable, Cost-Optimized, National Launch System Heat Shield
Remtech, Inc.
3304 Westmill Dr
Huntsville, AL 35805
Richard E. Somers (205-536-8581)

An innovative thermal protection system (TPS) is proposed for the base region National Launch System. This TPS would use certified materials, be designed to be semi-rigid, and would be adaptable to the contours of critical areas and components in the base region. The TPS will use a screen as the structural member to which RTV and/or metal foils and blankets could be attached. Different regions could use different compositions of the basic design depending on the anticipated heat load. Preliminary designs and thermal analyses of the base region with particular emphasis on the engine nozzles will be developed. The firm will also investigate manufacturing and application methods. Cost data will be input to a cost model to make preliminary assessments of the cost-effectiveness of various configurations. Phase II will further develop the TPS; test the various concepts thermally and structurally; and recommend specific designs, application techniques, and manufacturing processes.

Potential Commercial Applications: The thermal protection system (TPS) could be used on any number of future space vehicles. It could also be used as a replacement for bulkier, more expensive TPS on extant vehicles.

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223 MSFC
91-1-11.03-6688 NAS8-39303
Spray Combustion Stochastic Modeling Coupled with Laser Diagnostics
Aerometrics, Inc.
550 Del Rey Avenue, Unit A
Sunnyvale, CA 94086
Alejandro Brena De La Rosa (408-738-6688)

This project will investigate the parallel development of a novel stochastic model for drop and/or spray combustion and the development and implementation of sophisticated laser diagnostics to provide the necessary data to test and validate the numerical spray model. Stochastic methods have the potential of providing deep insight into the physical phenomena occurring in spray combustion, i.e., evaporation, mixing diffusion, chemical reaction, and the large fluctuation of the parameters which influence them. The objectives of Phase I are to develop a one-dimensional Monte Carlo model of drop and/or spray combustion; design and develop a test facility for burning single fuel drops; implement Lagrangian particle tracking (LPT) and rainbow thermometry (RT) experimental techniques to measure the velocity and the temperature of the liquid drops, respectively; investigate the feasibility of integrating the LPT and RT techniques for simultaneous measurement of velocity and temperature of the droplets; perform preliminary experiments with iso-octane and n-heptane to test the LPT and RT techniques; and compare with the predictions of the stochastic Monte Carlo model. Phase II will expand the model to a three-dimensional version with complete, finite-rate chemistry, turbulence modeling, and liquid-gas interphase coupling. A two-dimensional LPT

system will be developed. The RT system will be used with the firm's PDPA for testing and validation purposes.

Potential Commercial Applications: The stochastic spray model would have wide applications in the R&D and design of gas turbine engines, liquid rocket engines, incinerators, and other practical combustion systems.

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224 MSFC
91-1-11.04-4308 NAS8-39328
Micromechanical Model for Structural Response and Failure of Rapidly Heated, Carbon-Phenolic Laminates
Jortner Research & Engineering, Inc.
P.O. Box 2825
Costa Mesa, CA 92626
Julius Jortner (714-545-4308)

A micromechanical model will enable improved predictions of the stress-strain responses and fracture of carbon-phenolic laminates under rapid heating conditions. In contrast to current methods, which model structural behavior of ablatives using composite-material (macro) data as input, the new model would predict composite behavior from constituent-material (micro) data. Advantages would include a reduced need for full testing of each new composite made with the same fiber and matrix and an improved understanding of the physical phenomena underlying composite behavior in rapid-heating environments. This model would differ from conventional micromechanical representations of laminates by incorporating the development of porosity and pore-gas pressure during heating, by treating matrix strain capabilities in excess of 15 percent, and by including prediction of gas permeabilities. Phase I is aimed at establishing feasibility of a computer implementation of a model in a suitable form for use with (or within) finite-element structural analysis codes. Issues to be addressed include the mathematical formulation and the types of experimentation needed to define constituent input data.

Potential Commercial Applications: An analytical tool for predicting the behavior of composites during heating would have wide applicability, as heating is used in many composite manufacturing processes and there is a continual economic incentive to increase heating rates without damaging the material. The software developed could be marketed commercially as an add-on to general-purpose structural analysis codes.

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225 SSC
91-1-11.04-5649 NAS13-482
Holographic Depth Contouring
Daedalus Enterprises, Inc.
P.O. Box 1869
Ann Arbor, MI 48106
Karl G. Wesolowicz (313-769-5649)

This innovation integrates the well-developed theories of two-color holography and light striping with three new technological opportunities. These new technologies include easily-tunable pulsed lasers, high-frame-rate digitizing electronic cameras, and high-performance digital signal processors. Phase I will investigate the feasibility of integrating the above theories and technologies into a three-dimensional imaging system for non-intrusive measurement of deformation, vibration, stress, and nozzle thrust vector. This project applies to health monitoring sensors for solid-rocket-motor 1/components and interfaces. Critical proof-of-principle experiments will be carried out in an electronic holography laboratory and the resulting holographic image analyzed on a vision system using light-stripe analysis software. Phase I will produce a rudimentary design, performance model, and technical risk analysis.

Potential Commercial Applications: The holographic depth-contouring technology has two main areas of commercial potential: imaged three-dimensional metrology and imaged vibration analysis. End uses would be by firms manufacturing automobiles, aircraft, aerospace components, and audio speakers and other firms in which metrological and vibration imagery is important.

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226 LeRC
91-1-11.06-4167 NAS3-26327
Creating Turbine Discs from Explosively Welded Molybdenum-Niobium Laminates
Northwest Technology Industries, Inc.
547 Diamond Point Road
Sequim, WA 98382
Alan W. Hare (206-683-4167)

In current rocket engines there are problems with the short life span of turbine rocket discs. The goal of this project is to develop a new material for turbine discs constructed from laminated molybdenum-niobium. The technical objectives are to use explosive welding technology to bond sheets of niobium to sheets of molybdenum; bond multiple sheets of alternating molybdenum and niobium; perform tensile tests on molybdenum-niobium composites; and demonstrate that platinum can be bonded to niobium and molybdenum. If successful, sheets of molybdenum-niobium laminates will be tensile tested. These test results will show the suitability of the molybdenum-niobium laminate for use as a turbine disc. An improved disc could be used on engines such as the shuttle main engine which endure difficult conditions.

Potential Commercial Applications: If Phase II is successful, engine manufacturers could employ molybdenum-niobium turbine discs in jet engines.

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227 LeRC
91-1-11.07-1122 NAS3-26332
Multiple-Beam Spectroscopy for Liquid-Rocket-Engine Diagnostics
Science Research Laboratory, Inc.
15 Ward Street
Somerville, MA 02143
Stephen Fulghum (617-547-1122)

This project will demonstrate a powerful optical diagnostic that is fundamentally different from any technique presently used for rocket engine diagnostics. Like laser-induced fluorescence, it provides spatially localized information, but this technique does not require a laser. It utilizes the optical emission from the hot burning fuel. The emitted light can be detected optically and subsequently manipulated and separated into two components whose intensity difference is due only to optical emission from a spatially localized region within the luminous volume. This intensity difference is due to one spatial Fourier component of the light source distribution in the selected, localized region. Because of prior university development, a multiple-beam spectrometer can be designed, fabricated, and used for rocket engine diagnostics under an SBIR. Phase I will design an instrument, theoretically analyze its optics, and calculate its photon statistics. A proof-of-principle demonstration of this instrument will be performed at a rocket test facility during Phase II.

Potential Commercial Applications: A multiple-beam spectrometer would be valuable for laboratory investigation of many high-temperature gases. There is a potential market for a commercial instrument to fill this need.

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228 LeRC
91-1-11.07-9806 NAS3-26330
High-Performance Sapphire Windows
Advanced Fuel Research, Inc.
P.O. Box 380343
East Hartford, CT 06138-0343
Stephen C. Bates (203-528-9806)

The environment in the combustion chamber of a liquid rocket is too extreme to allow the use of large optical ports made from conventional materials. These ports are crucial for the non-intrusive measurements of combustion processes using advanced laser diagnostics that require high-quality, wide-aperture access. Specially processed and mounted sapphire windows will be developed to provide this optical access. Through surface treatments and proper consideration of thermal stresses, single crystal sapphire can be a mechanically equivalent replacement for high-strength steel. A prototype sapphire window design will be developed that uses processing of the exterior sapphire surface to achieve a reliable, large increase in mechanical strength. A simple high-pressure, high-temperature window test facility will be assembled and used to test processed sapphire samples and demonstrate the feasibility of the strengthening technique. Coupling strengthened sapphire windows with high-temperature mounting techniques will greatly expand capabilities for optical access to extreme environments, making laser diagnostics more flexible and possibly leading to entirely new diagnostic applications.

Potential Commercial Applications: Strengthened sapphire windows will lead to optical access for diagnosis of extreme environments. This is an enabling technology for broad research in combustion that has extensive commercial application for engines, burners, and furnaces.

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229 MSFC
91-1-11.08-0618 NAS8-39311
Highly Accurate, Adaptive Techniques for Damage Modeling and Life Prediction of Aerospace Structures
Computational Mechanics Company, Inc.
7701 North Lamar, Suite 200
Austin, TX 78752
W. Wojtek Tworzydlo (512-467-0618)

In the design of components of aerospace structures, such as Space Shuttle Main Engine, reliability considerations and life prediction are extremely important. There are several damage and fatigue theories designed to estimate reliability and life span of aerospace materials. The objective of this project is to combine these theories with adaptive finite-element methods in order to create a reliable and computationally efficient tool for the design of aerospace structures. Adaptive finite-element methods, based on rigorous error estimates, automatically adjust the structure of the computational mesh to provide the best solution at minimum computational cost. In practical applications this enables very large simulations to be conducted with a minimal number of degrees of freedom. The focus of this project is to couple adaptive methodologies with continuum damage theories and nonlinear constitutive material models in a three-dimensional finite-element code for predicting micro-crack nucleation and growth, and ultimate life expectancy for geometrically complex bodies subjected to complex time-dependent loadings. This code will be designed in a modular format to allow easy implementation and testing of constitutive theories and damage models. The final product will be a computational tool which functions on unstructured meshes and provides numerical results with a quantifiable level of accuracy and reliability.

Potential Commercial Applications: Advanced finite-element analysis of structural components with damage and fatigue modeling will be applicable not only to NASA's development of aerospace vehicles, but also in general engineering analysis of critical machine elements operating at high stress levels.

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230 MSFC
91-1-11.09-0250 NAS8-39307

Magnetic Suspension Bearings for Space Shuttle Main-Engine Turbopumps

Avcon-Advanced Controls Technology, Inc.
19151 Parthenia Street, Unit G
Northridge, CA 91324
Crawford R. Meeks (818-886-0250)

The reliability and performance of Space Shuttle main engines (SSME) are critical to mission launch success and safety. Currently, SSME reliability and performance are limited by turbopump bearing failure, both in the high-pressure liquid-oxygen and high-pressure fuel turbopumps (HPOTP and HPFTP). Current bearing limitations are related to high stresses and wear as well as to harsh (temperature and corrosion) environments. Magnetic bearing (MB) suspension technology can alleviate these problems because the MB actuator, sensor, and control system can compensate for uneven loading, suffer no wear, tolerate or seal-off corrosive agents. The applicability of MB to SSME has been limited by the MB size, weight, and power draw, as well as eddy current and hysteresis losses (which drastically limit practical RPMs). The company has a new class of MB designs that concurrently reduces size, weight, power draw, plus eddy current and hysteresis losses. The methodology of this new class of MB design is applied to SSME turbopumps designs. Near-term designs are based on state-of-the-art permanent magnets and high-efficiency magnetic materials. Far-term designs are based on high-temperature superconducting materials.

Potential Commercial Applications: This innovative technology would apply to radial and thrust bearings for military and commercial turbine engines; spindle and linear translator bearings of optical data storage disks; ultraprecision bearings for scanning spectrometers; replacement for air bearings in long-term, unattended applications; and bearings for heavy duty, low-maintenance compressors, and turbopumps.

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231 MSFC
91-1-11.09-4000 NAS8-39329

Experimental Method for the Extraction of Magnetic-Bearing-System Rotordynamic Coefficients

Kingsbury, Inc.
10385 Drummond Road
Philadelphia, PA 19154
Joseph Imlach (215-824-4888)

An experimental method will be developed for measuring the dynamic stiffness and damping coefficients of magnetic bearings and controller systems. No method or facility currently exists for the experimental validation of these coefficients. These experimental results will be beneficial in validating current design models and for evaluating the applicability of various magnetic bearing systems to such machines as the SSME turbopumps, as well as multiple commercial applications. The steps required to achieve this objective include: selection of candidate rotordynamic coefficient extraction techniques for magnetic bearings and controller systems based on a review and evaluation of existing techniques for fluid film bearings and seals; selection of candidate magnetic bearing designs to be investigated based on suitability to space applications; and development of a coefficient extraction technique and definition of a test rig configuration necessary to implement the technique. A test procedure and facility for standardized testing of magnetic bearing systems will be developed. This will have the effect of providing independent verification of applicability of magnetic bearing systems in various applications. It will also provide information for the continued improvement of magnetic bearing system design.

Potential Commercial Applications: The resulting method will be useful to all magnetic bearing manufacturers and users who wish to improve the design of or evaluate competing magnetic bearing systems.

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232 JSC
91-1-11.10-0236 NAS9-18698

Monolithic, Noble-Metal Catalysts for Hydrogen-Oxygen Thrusters

Ultramet
12173 Montague Street
Pacoima, CA 91331
Robert H. Tuffias (818-899-0236)

Catalytic igniters offer the potential for excellent reliability and simplicity for use with the diergolic bipropellant hydrogen and oxygen. State-of-the-art catalytic beds--noble metals on granular pellet carriers--are currently limited by carrier stability, which limits the hot-fire temperature, and by poor thermal response due to the large thermal mass. Questions remain with regard to longevity and reliability of these catalysts. Phase I will demonstrate the feasibility of fabricating monolithic catalysts beds that overcome the limitations of current catalytic igniters. The approach is an innovative combination of unique developments in chemical-vapor-deposition iridium coatings and chemical-vapor-infiltration refractory ceramic foams. Successful development of monolithic catalytic igniters would greatly improve upon the state-of-the-art, enhancing performance and reliability while reducing cost and weight. Reduced weight is the principal advantage of catalytic ignition over other alternatives, such as spark torch or hypergolic ignition. For small thrusters, such as auxiliary propulsion, the igniter weight is critical, but larger engines that make use of multiple igniters in a baffled configuration and upper stage engines with multiple restart capability would also realize a weight savings benefit from this technology.

Potential Commercial Applications: A simple, reliable, lightweight igniter for hydrogen and oxygen can be applied to a wide range of engine sizes, from relatively small auxiliary propulsion and vernier control thrusters to large, baffled, multiple igniter engines, and upper stage, multiple ignition engines.

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233 LeRC
91-1-11.10-5307 NAS3-26323
Hydrocarbon-Liquid-Oxygen Monopropellants
Wickman Spacecraft & Propulsion Company
P.O. Box 7179
Citrus Heights, CA 95621-7179
John W. Wickman (916-728-5307)

Liquid oxygen monopropellants may be part of an emerging propulsion technology. This project will research how to make monopropellants from low-cost, high-performance fuel sources. Coal, kerosene, and natural gas will be some of the candidate fuels to be mixed with liquid oxygen.

Potential Commercial Applications: Potential applications include Shuttle II, new launch vehicles, and sounding rockets. Commercial launch vehicles using these rocket engines and monopropellants could help bring the cost of access to space resources to a profitable level.

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234 JPL
91-1-11.11-0046 NAS7-1175
Pre-Formed Solenoid Magnets from High-Temperature Superconductors
Superconix, Inc.
261 East Fifth Street
Saint Paul, MN 55101
Charles Gallo (612-222-0046)

Several electric propulsion schemes utilizing magnetic solenoids have been proposed for space propulsion. To minimize weight, size, power and refrigeration, magnets made from the new high-temperature superconductors are attractive. Although the new high-temperature superconductors are revolutionary, they are brittle and difficult to fabricate into flexible wires with high current capacity. Even though considerable progress has been made on several alternative wire fabrication techniques, the firm will produce high-temperature superconducting magnets with proprietary pre-formed techniques that are much simpler and minimize size, cost, and weight. This circumvents many of the fabrication and low current problems. Some novel magnet design concepts and associated power supplies will be developed.

Potential Commercial Applications: If the novel magnet designs and constructions in this project are successful, the first commercial products would be laboratory magnets (small, simple, light, inexpensive) from which large-scale applications would eventually evolve.

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235 MSFC
91-1-11.12-7652 NAS8-39318
Failsafe, Multistrand, Tether Structures for Space Propulsion
Forward Unlimited
P.O. Box 2783
Malibu, CA 90265-7783
Robert L. Forward (805-983-7652)

Long cables or tethers operated in various modes (gradient stabilized, librating, rotating, or pumped) have often been proposed for space propulsion. The tether is a mechanism that transfers energy and momentum to or from a space vehicle from the tether, planetoid, or some other space vehicle. A number of experiments will be conducted to demonstrate this advanced space propulsion technique using single-strand tethers. Damage estimates to the tether by space debris, however, indicate that the average lifetime of a long single-strand tether is only about one month. The goal of this project is to design and analytically and experimentally analyze a failsafe, multistrand tether structure for space propulsion that will maintain its overall structured integrity and mission capability under multiple severings by space debris, while still being capable of deployment and retrieval using relatively simple reeling apparatus. The availability of a long-life, reliable tether structure will allow NASA to seriously consider this advanced space propulsion system, which, when properly designed, can repeatedly move payloads between LEO and GEO, into deep space, and to the surface of the moon and Mars, without requiring refueling.

Potential Commercial Applications: Compared to chemical rockets, tethers are inexpensive, lightweight, reusable, and easy for small businesses to develop, test, and deploy. They are of simple construction and use no hazardous or exotic materials. Early commercial applications will be for the transfer of payloads between LEO to GEO. Later applications will include transfer of payloads from LEO to the surfaces of the Moon and Mars.

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236 JPL
91-1-11.12-9915 NAS7-1183
Particle Simulation of Grid Erosion for a Three-Grid Ion Thruster
ERC, Inc.
P.O. Box 417
Tullahoma, TN 37388
Quan Zhang (615-455-9915)

Phase I will simulate the grid erosion of the innovative triple-grid accelerating system of an ion engine. The

project will determine the feasibility of using a particle simulation model for the triple-grid accelerating system in order to study ion optics, charge exchange collision, and grid erosion processes in an ion thruster. The model has been successfully applied to a two-grid accelerating system to study the accelerator grid erosion. Using the new model, the accelerator grid erosion in a triple-grid accelerating system will be studied. These simulations will be used to interpret and guide experimental investigations at NASA. Phase II will investigate grid erosion of ion engines through a combined experimental and theoretical effort. The grid geometries and voltages will be varied to reduce the grid erosion and improve performance. A high-performance, long-duration, triple-grid accelerating system will be developed in Phase II for ion propulsion use during space missions.

Potential Commercial Applications: The triple-grid erosion simulation code can be marketed as a design tool for ion engines for space propulsion. On the hardware side, high-performance, low-erosion accelerator grids will be developed using this code as a guide to be used in ion engines.

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12: Human Habitability and Biology in Space

237 JSC
91-1-12.01-4220 NAS9-18703
Monitoring Immune Function by Detection of Cytokines in Human Saliva
Assay Research, Inc.
Bldg 335, Paint Branch Drive
College Park, MD 30742
Lawrence Tamarkin (301-445-4220)

The effect of space travel on the functioning of the immune system appears to be correlated with the incidence of infection. Post-mission findings demonstrated a suppression of some aspects of the immune system. However, these studies for the most part required invasive procedures such as phlebotomy to obtain lymphoid cells. A novel non-invasive method for monitoring immunocompetence monitoring by the salivary concentrations of four cytokines (IL-1α, IL-2 IFNα and IFNγ) will be explored. The validation of these measures will be done by HPLC and Western Blot analysis of saliva containing immunoreactive cytokines. In addition, salivary cytokine stability studies will be performed. The biological significance of these measures will be demonstrated by determining if the salivary concentrations of these cytokines change in response to various stressors. The data obtained from these studies will lead to a better understanding of both static and dynamic aspects of the immune system and, in particular, the mucosal immune system, that may change during space missions.

Potential Commercial Applications: A valid non-invasive method for monitoring immune function will be a new tool for patient screening. The commercial potential for the technology exceeds the large critical care market and is appropriate for at-home monitoring of patients and healthy individuals for disease risk.

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238 JSC
91-1-12.01-9027 NAS9-18682
An Artificial-Intelligence Aid for Crew Assessment and Mission Management
Owen Research
P.O. Box 17382
Boulder, CO 80308-7382
Robert B. Owen (303-441-9027)

Future spacecraft crews will live in closed environments for months at a time. Studies of isolated groups show that social considerations are important in optimizing crew health and performance. A computer simulation of social group dynamics based on artificial intelligence, which is less expensive than direct human tests, will be developed for extended duration mission management and crew assessment. This approach will emphasize formal and informal structural group dynamics. The simulation will explicitly model the formal, or "official," social structure of the spacecraft environment. Case-based reasoning will be used to move from one state to the next, and the simulation will learn using data from these studies. This approach will overcome many of the current limitations of expert systems, which generally have no learning capability. A truly predictive model is not expected. What is expected is that a simulation run will tell even an expert something new. The program will be able to augment a human expert who is making mission management or crew assessment decisions.

Potential Commercial Applications: This aid could be used in personnel selection, training, and management of isolated and confined small groups in oil stations, polar bases, oceanographic vessels, missile silos, submarines, and other locations where crew health and performance in extreme environments are concerns.

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239 JSC
91-1-12.02-3300 NAS9-18701
Microbial Evaluation in Space Station Using New Hexoid Plates
Xechem, Inc.
100 Jersey Avenue, Building B, Suite 310
New Brunswick, NJ 08901-3279
Ramesh C. Pandey (908-247-3300)

Microorganisms are likely to have a serious impact on NASA's manned space exploration program. The intent of this project is to develop new hexoid plates for microbial testing of clinical and environmental specimens. The hexoid plates will have a set of simple,

reliable, lightweight dehydrated culture media that have extra-long shelf-life and sensitivity and can be reconstituted when required. New hexoid plates will be tested and compared with conventional plates regarding their space, time, and efficiency. Similarly, the new media formulation will be tested and compared with conventional dehydrated media regarding the efficiency of detecting the microorganisms. The conventional calibrated 0.001-ml loop method will be used in the new hexoid plates with filter and medium to demonstrate the sensitivity of the new formulation. The comparison of the formulation to commercially available "Qualture" plates regarding sensitivity to microbial growth will be carried out. It is anticipated that the technique will allow detection of up to six organisms simultaneously. The technique could be very useful in evaluating environmental contamination aboard the space shuttle and to check the body fluids of astronauts for possible infections.

Potential Commercial Applications: These hexoid plates could be useful both in testing of drugs on microorganisms in space capsules as well as in microbiology laboratories and hospitals on Earth.

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240 JSC
91-1-12.02-7770 NAS9-18683
Inflight Ammonia Monitor
Umpqua Research Company
P.O. Box 791
Myrtle Creek, OR 97457-0118
James R. Akse (503-863-7770)

Conventional methods for ammonia analysis depend on wet chemical techniques or ion-selective electrodes which are unstable. The innovation to be developed in this project is a sequential process for determining the ammonia concentration in an aqueous stream which may contain other contaminants. This process contains three major steps. Volatile species such as carbon dioxide which may interfere with the later selective segregation of ammonia are eliminated. Second, a liquid-liquid exchange across a vapor channel in a microporous membrane will equilibrate the aqueous stream's ammonia level with that in the analytical cell. Dependant on the ammonium species present, a solid-phase metal-oxide base may be incorporated to shift any equilibrium towards ammonia. The final step is a conducto-metric measurement or an electrochemical, oxidation-reduction probe to determine the ammonia concentration in the analytical stream. This analytical technique will offer a reliable interference free method.

Potential Commercial Applications: Applications may include use as an industrial on-line ammonia monitor or laboratory ammonia analyzer

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241 JSC
91-1-12.02-7818 NAS9-18671
Calcium Absorption Using Stable Isotopes and Saliva
Eastern Analytical, Inc.
335 Paint Branch Drive
College Park, MD 20742
Larry J. Moore (301-314-7818)

Loss of calcium bone mass during exposure to microgravity is a serious concern for the space station crew due to the probability of prolonged exposures. Rather than use radioisotopes for in-flight metabolic studies, stable calcium isotopes will be employed as tracers for convenient, noninvasive determinations of calcium absorption and related metabolic indicators. Saliva will be the body fluid to be used in this method. Analytical methods will be developed using chemical separations and thermal ionization mass spectrometry, initially, leading to the utilization of a highly efficient calcium isotopic analysis system based on auto-ionization-mediated laser photo-ionization. An examination of the calcium dynamics for pre-flight, in-flight, and post-flight periods may provide insight into the mechanisms of bone demineralization. A pilot study will be conducted parallel with ongoing tracer experiments, and the results will be directly compared with those acquired under standard conditions. The technical objectives are to develop a method to separate calcium from saliva; demonstrate the ability to atomize, ionize, and determine isotope ratios of calcium separated from the saliva matrix; conduct ground-based calcium dynamics experiments using calcium stable isotope tracers as part of an ongoing NASA bone demineralization study for SLS-1 and SLS-2 flights; and assess the results to determine the analytical and biomedical viability of saliva for calcium absorption measurements.

Potential Commercial Applications: Commercial applications of this research are expected to evolve from a potentially large market for clinical diagnostic measurements of calcium absorption and for instrumentation, materials (kits), and processes related to the technology.

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242 ARC
91-1-12.03-3474 NAS2-13532
Hybrid Processor for Physiological Artifact Detection
Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, MA 02138
Greg L. Zacharias (617-491-3474)

Phase I will evaluate the feasibility of developing a hybrid physiological artifact detection system from two complementary artificial intelligence (AI) technologies: artificial neural networks (ANNs) and knowledge-based expert systems (ESs). By hybridizing these two technologies, computer-based pattern recognition (via ANNs)

will be combined with a human expert's knowledge of physiological signal recording characteristics (via ESs). This hybrid detector will be developed within the existing NueX software development environment which supports synergistic interaction between ANNs and kbESs. The envisioned prototype artifact detection processor will support dynamic updating of the physiological signal knowledge base, via the artifact recognition capabilities of the ANN, and result in continuous learning by the ANN, via the recording paradigm knowledge stored in the ES. Feasibility will be evaluated by defining the scope of the problem and identifying candidate solutions; designing and implementing a prototype hybrid detector; demonstrating and evaluating detector performance; and specifying hardware and software system design requirements for Phase II implementation of a real-time system.

Potential Commercial Applications: Commercial potential exists for the end product itself, a generic physiological artifact detector, and for the hybrid software environment used to develop it. The hybrid processor holds promise for inclusion in a wide range of existing physiological instrumentation systems. The development software can serve as the basis of such other signal detection and/or isolation applications as exist in the area of fault detection and/or isolation and safety monitoring.

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243 JSC
91-1-12.04-1583A NAS9-18688
Advanced, Intermediate-Temperature, Electrolytic Cell for Oxygen Generation from Martian Atmospheric Carbon Dioxide

Eltron Research, Inc.
4260 Westbrook Drive
Aurora, IL 60504
Anthony F. Sammells (708-898-1583)

This project will investigate solid-state electrolytic cells for the direct removal of oxygen from CO_2 over the temperature range of 400 to 600°C. Effective separation between the cell cathode, where carbon dioxide becomes reduced to carbon monoxide, and the anode, where oxygen evolution occurs, will be achieved by utilizing O^{2-} conducting, brownmillerite, solid electrolytes that have demonstrated significantly higher ionic conductivities than those with materials based upon the stabilized zirconias. This will permit electrolytic cell operation at intermediate temperatures. Electrocatalysis for enhancing the kinetics of electrochemical CO_2 reduction will be achieved using brownmillerite-based cathodes of general stoichiometry $A_{2-x}A'_xB_2O_5$, where A = Ba or Sr, A' = Ce or Dy, and B = Co, Ni or Cu which will be expected to provide favorable CO_2 adsorption characteristics while at the same time possess the required high ionic (O^{2-}) and electronic conductivities at intermediate temperatures. The overall electrolytic cell will permit high electrochemical rates to be achieved for the efficient removal of oxygen for breathing from CO_2 under Martian atmospheric conditions. The carbon monoxide effluent from electrochemical cells can then be utilized in the reduction of iron ores present in large quantities on the Martian surface to metallic iron.

Potential Commercial Applications: This electrolytic technology would provide a viable process for the extraction of oxygen from carbon dioxide in the Martian atmosphere for the maintenance of life. The separated cathodic reaction product (CO) could also be used either directly or indirectly as a reducing agent on the Martian surface for Martian ore refining.

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244 JSC
91-1-12.04-1980 NAS9-18690
Electrochemical Reduction of Carbon-Dioxide Using a Novel Electrode System

Materials & Electrochemical Research
7960 South Kolb Road
Tucson, AZ 85706
Raouf O. Loutfy (602-574-1980)

Newly discovered C_{60} carbon exhibits unique electrochemical behavior. Its properties will be investigated to evaluate its ability to reduce CO_2 electrochemically and produce oxygen for air revitalization in manned space stations. Electrolytes appropriate for the catalytic electrochemical reduction will be investigated. The electrochemical behavior of C_{60} electrodes will be established using cyclic voltammetry. A two-ampere laboratory electrochemical cell will be operated to establish the feasibility of the concept. Phase I will establish the optimum cathode material, anode efficiency, cell voltages, operating current density, and material balance by operating a five-ampere cell for extended time periods. The definition of these variables will lead to the determination of the economics of the overall process.

Potential Commercial Applications: A new class of electrochemical reactions made possible by C_{60} could further expand to other electrochemical synthesis reactions and fuel cells for power generators.

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245 JSC
91-1-12.04-2228 NAS9-18695
Removal of Nitrogen from Carbon-Dioxide-Rich Streams

Membrane Technology & Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
Richard W. Baker (415-328-2228)

The objective of this project is to develop a membrane process for removing nitrogen from carbon-dioxide-rich gas streams. Manned space vehicles on long missions must use regenerative life-support systems. Although a variety of techniques exist for con-

verting carbon dioxide back into oxygen, they require that the nitrogen content of the carbon dioxide feed stream be reduced to less than 0.2 percent. Current separation techniques are energy-intensive and unsuited for spacecrafts because of their bulk, weight, and complexity. A membrane process would be compact and lightweight, and use less energy. The membrane process to be developed is based on composite membranes prepared with rubbery materials like the perm-selective layer. The selective materials of choice will have a low permeability for nitrogen and a high permeability for carbon dioxide. The composite membranes will be tested with pressurized mixtures of carbon dioxide and nitrogen. In preliminary work, a membrane has already been established that has a selectivity value for carbon dioxide from nitrogen of 60 and a carbon dioxide normalized flux of $3x10^{-4}cm^3(STP)/cm^2$ sec cmHg. These values would make a small, lightweight membrane system that could deliver purified carbon dioxide at a recovery rate of 97.5 percent possible. Phase I will prepare and evaluate membranes, first as discs in laboratory cells, later as small spiral-wound membrane modules. Based on the results, an engineering analysis of the nitrogen removal process will be performed, and its suitability for development into a prototype system in Phase II program will be determined.

Potential Commercial Applications: Besides its use in spacecraft, a membrane system that could separate carbon dioxide efficiently from other gases would have an enormous potential in natural gas processing.

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246 ARC
91-1-12.04-3149 NAS2-13526
Integrated System for Resource Recovery from Multiple Waste Streams
Lynntech, Inc.
111 East 27th Street, Suite 204
Bryan, TX 77803
G. Duncan Hitchens (409-822-3149)

Waste processing for recovery of reusable resources is an essential, but highly complex, requirement for reducing resupply for a closed ecological life-support system. There is an urgent need for a safe, energy-efficient and spaceflight-compatible waste-processing capability for recovering water, carbon dioxide, nitrogen, and minerals from diversified waste streams. The company has developed an advanced oxidation system for solid-waste processing and resource recovery that is based on a unique air-depolarized electrochemical cell. The oxidation system operates without expendable items and is characterized by several physical and chemical system advantages. A major problem with current electrochemical systems, i.e., the lack of a sufficient oxidizing environment to treat both liquid and solid wastes from all sources, can be overcome using the electrochemically based advanced oxidation system. Preliminary results from a pilot oxidation system demonstrated that the process was capable of completely decomposing inedible plant biomass (cornstalks). Test data also shows that hygiene water of potable quality can readily be recovered from this unit.

Potential Commercial Applications: This system is applicable to hazardous waste and industrial effluent clean-up, e.g., destruction of chlorinated hydrocarbon pollutants.

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247 JSC
91-1-12.04-3200 NAS9-18667
High-Solids, Packed-Bed, Plug-Flow, Microbial, Solid-Waste Processing Module for Space Applications
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Harris Gold (617-890-3200)

Future space missions, such as Space Station Freedom, the Lunar Base, and Mission to Mars, will involve prolonged life in space, placing new demands on closed loop environmental control and life-support system technology. Regenerative systems, which have already been developed for air and water management because of the magnitude of resupply requirements, will also be required for solid waste management. In particular, bio-regenerative systems become necessary as mission duration and resupply distances increase. An innovative bioreactor will be developed incorporating a high-solids, packed-bed, plug-flow design operating in micro- or partial-gravity environments. The system provides high levels of biological stabilization of organic waste, while minimizing reactor volume, residual solids storage, and energy input requirements. This unique bioreactor design concept, specifically adapted for space applications, overcomes equipment size and mass transfer limitations associated with biological systems in space.

Potential Commercial Applications: Applications include: modular industrial waste treatment for high-suspended-solids streams; production of specialty chemicals from agricultural residues and biomass; and micro-packaged waste treatment processes (marine, RV applications).

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248 JSC
91-1-12.04-3291B NAS9-18699
Electrochemical Ozone Generator for In Situ Sterilization of Potable Water and Wastewater
Life Systems, Inc.
24755 Highpoint Road
Cleveland, OH 44122
Ronald J. Davenport (216-464-3291)

The electrochemical ozone generator (EOG) can generate and dispense ozone (O_3) to sterilize potable

water and wastewaters. Ozone is generated by electrochemically oxidizing water at ambient temperature using no expendables or coolant and little power. The EOG is unique because it contains no hazardous materials; it does not contain the lead oxide (PbO_2)electrodes or acidic electrolytes used in other electrochemical O_3 generators. Other advantages include the fact that O_3 sterilizes more effectively than most other biocides. Ozone does not degrade the taste of potable water or form halogenated organics. Unlike solid biocides such as oxone, ozone can be dispensed easily and accurately. The amount of O_3 dispensed can be readily controlled by adjusting the current to the EOG. The EOG contains no biocide when it is not operating, so transportation and maintenance procedures are simple and safe, even in a zero-G environment.

Potential Commercial Applications: Commercial applications would apply to such uses as water disinfection, accelerated ozone testing hardware, organic contamination removal, and odor elimination.

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249 MSFC
91-1-12.04-7918 NAS8-39344
Catalysts for the Oxidation of Trace Contaminants
TDA Research, Inc.
12421 West 49th Avenue, Unit 6
Wheat Ridge, CO 80033
John D. Wright (303-422-7953)

Long-duration manned missions require control of trace organic contaminants in the spacecraft atmosphere. One option is catalytic oxidation. The catalysts must have the ability to oxidize multiple compounds, resist poisons, and operate at the lowest possible temperature. Most systems use supported noble metal catalysts. A new class of catalysts are poison-resistant oxidation catalysts for CO and H_2 (major spacecraft contaminants) at extremely low (-70°C) temperatures. Because the rate-determining step for hydrocarbons is the same as that for CO, such catalysts should also carry out the oxidation of hydrocarbons contaminants at lower temperatures than current noble metal catalysts. In Phase I, the project will make several low-temperature oxidation catalysts and test them against four model contaminants (CO, CH_4, toluene, and methyl ethyl ketone). The most promising low-temperature catalysts will then be tested in the presence of water vapor. The best catalyst will then be coated on a low-pressure-drop monolithic support and tested against the model contaminants. Phase II will further develop and test their activity on multiple compounds, evaluate the effect of poisons, and fabricate a breadboard catalytic oxidizer.

Potential Commercial Applications: Low-temperature CO oxidation catalysts are immediately applicable to gas clean up in ammonia synthesis and fuel cells, and in the longer term, to automotive catalytic converters. Low-temperature oxidation of organics is useful in solvent emissions control. The catalyst materials are also much less expensive than noble metals.

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250 ARC
91-1-12.05-3088 NAS2-13517
Lightweight, Fiber-Optic, Gas Sensor for Monitoring Regenerative Food Production
Physical Optics Corporation, R&D Division
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Edward Schmidlin (213-320-3088)

This project addresses an innovative system, based on porous optical fibers impregnated with sensor dyes, that can monitor of gases in regenerative food production facilities. The firm has been involved in commercializing this new technology for approximately a year. Essentially, porous fibers provide an immobilization substrate for chemical indicator dyes in this novel "optrode" style sensing technique. The porous optrode is attached to a conventional optical fiber and illuminated at a wavelength, or set of wavelengths, characteristic of the selected indicator dye. As a gaseous substance diffuses into the porous structure and interacts with the sensor dye, a change in optical absorbance, wavelength lifetime, or fluorescence intensity is observed. This optical change can be monitored using simple fiber optic components and inexpensive photodetectors. Advantages of fiber optic sensor systems when used in spacecraft include low weight, small size, high reliability (all solid-state components), and low power usage. In addition, porous fiber sensors are easy to produce, potentially very rugged, well-suited to the measurement of O_2, CO_2, humidity, and other gaseous chemical species, and should be unaffected by low-gravity situations.

Potential Commercial Applications: The fiber-optic gas sensor has the potential to detect nearly any gas for which an indicator dye exists, so there are many potential applications for this technology. Sensors developed specifically for this program would have immediate applications in the food processing and biotechnology industries.

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251 KSC
91-1-12.05-7070A NAS10-11861
In Situ Sensors for Plant Growth Experiments
Geo-Centers, Inc.
7 Wells Avenue
Newton Center, MA 02159
Mary Beth Tabacco (617-964-7070)

This project will utilize chemical optrode technology combined with distributed sensing and multiplexing techniques to create a system to monitor potentially toxic vapors in situ and in real time. Chemical optrode technology has been demonstrated for highly sensitive

detection of chemical species important in plant growth and respiratory gas exchange experiments. Distributed sensing and multiplexing techniques are under-utilized in chemical detection systems. The goal of this project is to develop a multi-sensor system for monitoring low levels of gaseous species important in plant growth experiments. Phase I will further develop and test ethylene and ammonia sensors in a field application and distributed sensing and multiplexing techniques will be reviewed and conceptual designs generated for complete monitoring systems. A prototype multi-sensor, trace-gas monitoring system will be developed and field evaluated in Phase II. The expected result is a simple, cost-effective, and integrated approach to trace-gas monitoring and control.

Potential Commercial Applications: Ethylene optrodes would have commercial potential wherever harvested crops are stored or transported and in greenhouses. Ammonia optrodes could be used to monitor agricultural runoff and to manage fertilizer application in real time. A multi-sensor, trace-gas monitoring system would find broad application wherever there is a potential for low levels of potentially toxic vapors to accumulate, such as chemical laboratories, chemical manufacturing facilities, aircraft, and spacecraft.

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252 MSFC
91-1-12.06-1145 NAS8-39331
Light-Driven, Waste-Remediation System Utilizing Phototrophic Bacteria
Micro-Bac International, Inc.
9607 Gray Boulevard
Austin, TX 78758
Dennis Ray Schneider (512-837-1145)

A new waste treatment system based upon photoassimilation of organic compounds by phototrophic bacteria will be developed. A critical problem for long-term space habitation is the need to continuously detoxify and decompose organic waste materials and allow their recycling in a closed system. Phototrophic bacteria utilize unique biochemical pathways for organic oxidation that offer significant advantages over conventional aerobic or anaerobic systems. These include minimal gas generation or utilization, resistance to shock loading and chemical toxicity, and reduced energy requirements. As part of the project, various strains of phototrophic bacteria, optimal for waste decomposition, will be selected. Prototype light-driven waste treatment systems will be constructed and inoculated with these strains. The optimal prototype will be operated for an extended continuous period (60 days). Performance standards to be met will be 95 percent or greater for removal of waste components. The ability of the system to remove toxic compounds such as naphthalene will also be evaluated. Biomass generated by the phototrophs will be evaluated for its ability to support plant growth and be recycled in the biosphere.

Potential Commercial Applications: Similar systems could be used for small- and large-scale sewage treatment with greatly improved efficiency and lower operating costs. These could include isolated communities and farms as well as Third World communities. Such systems could also be used to detoxify waste streams from large-scale chemical and food processing plants.

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253 JSC
91-1-12.07-2040 NAS9-18692
Nonstandard Functional Limb Trajectories
Moco, Inc.
P.O. Box A
Scituate, MA 02055
Ruth A. Maulucci (617-545-2040)

The goals of this project are to investigate experimentally the effect of nonstandard conditions on functional limb movements and to use the acquired data to develop generalized theoretical models. The project objectives are to examine functional limb movements, such as reaching, kicking, or ambulating, under such nonstandard conditions as limb loading, muscle fatigue, external perturbations, path obstacles, and environmental changes. The innovation's focus is on movements that are embedded in non-ideal circumstances commonly found in natural daily living activities, and in the culmination of a mathematical model that will permit empirical results to be generalized for unique situations. The work should prove relevant to human factors for space crews since the biomechanical data encompasses crew performance in spaceflight conditions and the dynamic model can serve as an applied design model for enhancing human productivity in space. The results will be implemented in an interactive software system with which design engineers can examine the effects of different nonstandard conditions on limb trajectories.

Potential Commercial Applications: The software system resulting from this project will have commercial application for design engineers who must consider human factors, specifically limb trajectories, in their designs. The results will also have applications in rehabilitation, where arm loading and fatigue are concerns in therapeutic intervention and perturbations and path obstacles are issues in prosthetics and orthotics.

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254 ARC
91-1-12.08-4949 NAS2-13555
Virtual Environment Interface
S-Tron
303 Ravendale Drive
Mountain View, CA 94043
Oliver J. Edwards (415-903-4949)

This project involves an assessment of practical near-term technology for miniature flat-panel displays that can deliver megapixel resolution at video rates. Improvements over current methods of head tracking will also be obtained. Specific technical options to address these needs will be investigated.

Potential Commercial Applications: Broad commercial applications exist for a miniature, high- resolution, head-worn display, including all mobile information workers and entertainment consumers.

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255 JSC
91-1-12.10-8100A NAS9-18684
Space Station Stowage Management System
Aptek, Inc.
1257 Lake Plaza Drive
Colorado Springs, CO 80906-3578
Jerry L. Udy (719-576-8100)

This innovation will provide NASA with a computer database management system and schematic graphical user interface (GUI) for space station stowage configuration control. This system will be used to support the determination of Space Station Freedom (SSF) mission stowage configurations. The DBMS and GUI will be linked with software that facilitates the placement of three-dimensional objects into individual stowage trays and then produces the stowage-configuration control drawings. When completed and linked with the three-dimensional and configuration control drawing databases, the system will provide NASA personnel with a tool for placing or finding items anywhere in the SSF. This innovation is needed because no system currently exists for the purpose of determining SSF stowage configurations. NASA personnel have recognized that this is needed and that it is the next logical step to the work currently underway.

Potential Commercial Applications: Stowage database management systems would be beneficial in most operations where stowage, storage, inventory management, and tracking are important.

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256 JSC
91-1-12.11-0560A NAS9-18672
Space-Suit Glove Tester
Sarcos Research Corporation
261 East 300 South, Suite 150
Salt Lake City, UT 84111
D. Kent Backman (801-531-0559)

Methods are not currently available for realistically assessing space-suit glove design parameters in a repeatable fashion. Quantitative evaluations of relative comfort, activation forces and torques, mobility, and fatigue life are essential to help advance the state-of-the-art in glove technology. Using humans to evaluate glove design produces no quantitative information and is highly subjective. Furthermore, it does not allow high-cycle life-testing and comprehensive failure mode identification to be carried out. This project will design a complete glove testing system that is capable of actuating a glove with a human-like robot hand. It will be able to perform high precision measurement and control of load, torque, and position, and remove human subjectivity from the results. The device will assist in establishing failure modes and operational limits of space-suit gloves of various designs over the range of operating pressures to be encountered in service. The result would be the standardization of space-suit glove evaluation and testing procedures that would enable the introduction of a meaningful quality assurance program.

Potential Commercial Applications: The glove tester is a robust, anthropomorphic, fully instrumented end-effector that has commercial applications in the many areas of robotics where both dexterity and reliability are required. The glove testing system will be marketed to the glove and clothing industries as well as to NASA and other government agencies.

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257 ARC
91-1-12.11-1622 NAS2-13506
Material with Exceptional Properties for Extravehicular Thermal Management
Rasor Associates, Inc.
253 Humboldt Court
Sunnyvale, CA 94089
Jean-Louis Desplat (408-734-1622)

A new class of micro-structural material, K-Max, has been developed with exceptional heat transfer properties that can relieve or accommodate many of the constraints of space suit thermal management. The local thermal conductivity of K-Max can be varied rapidly from that of a good insulator to many times greater than that of a metallic conductor. A compliant K-Max body covering can automatically maintain constant local body temperature when the local heat flow and heat rejection temperature vary widely. K-Max can be formed into virtually any shape with a wide variety of compositions. Phase I will survey space suit needs and define specific applications that can benefit from the use of K-Max, including both passive and active body cooling. A specific K-Max spacesuit component will be selected for detailed analysis and evaluation, and for comparison of the K-Max component with conventional components. A detailed program plan will be prepared for Phase II development and preprototype demonstration. A deliverable mock-up demonstrator will be prepared in Phase I to demonstrate credibility of the novel heat transfer process to be employed in Phase II.

Potential Commercial Applications: The project will develop novel know-how and technology that will have

wide applicability to a family of temperature-regulating body coverings for aerospace and other commercial applications.

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258 JSC
91-1-12.11-3200 NAS9-18666
A Subcritical Liquid Oxygen System
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
David H Walker (617-890-3200)

The present primary life-support system (PLSS) utilizes high-pressure gaseous oxygen for operation. This presents a significant safety risk and potential logistics problems for future missions. The use of subcritical, liquid oxygen for the PLSS offers many advantages, but previous attempts at using LOX have not succeeded due to such problems as pressurization and dealing with a two-phase flow in a microgravity environment. A subcritical LOX system that is capable of addressing these problems has been devised while delivering the benefits of reduced system weight and volume (28 and 79 percent, respectively) and eliminating the hazards of high-pressure oxygen systems. This system employs a cryogenic tank equipped with a flexible bladder constructed from a liquid crystal polymer (LCP) material, and a helium gas spring that maintains the LOX in a subcooled state, preventing vapor formation, maintaining system pressure, and making the tasks of metering and inventory measurement relatively easy.

Potential Commercial Applications: Liquid oxygen is often used in military aircraft where the proposed system would be an improvement over those now in use. Other mobile applications, such as underwater activities, fire fighting, or medical emergencies, may benefit from this technology.

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259 JSC
91-1-12.11-5668 NAS9-18710
A Ceramic-Film, Corrosion-Protection Barrier for Heat Exchanger Components
TPL, Inc.
3754 Hawkins NE
Albuquerque, NM 87109
Richard W. Brotzman (505-345-5668)

Heat exchanger components, normally fabricated from aluminum, are subject to corrosion and leaching of unwanted materials into the fluid stream over the 15 to 30 year lifetime of the system. Conventional coating techniques are not viable because of poor access to internal surfaces of the involved components. A unique sol-gel-derived aluminosilicate composition with extremely low surface area properties resulting in hermetic properties has been formulated at low processing temperatures. Applications techniques, including dip coating, are being developed which allow this ceramic composition to be considered as a protective barrier for a variety of applications. A reactive primer technology has concurrently been developed which insures coating adherence to a wide range of substrate materials. A dip coating technique for the aluminosilicate will be developed for internal surfaces which will provide heat exchanger protection. Dip coating parameters will be investigated for different component geometries. Hermetic properties of the coating deposited on complex substrates will be investigated against water vapor. Protection of aluminum from corrosion in an accelerated aging test will be established.

Potential Commercial Applications: Numerous applications exist for a ceramic hermetic sealing material which can be applied and processed at low temperatures. These include microelectronic hermetic seals, protection for medical implant devices, protection of food and drink packages, broad area corrosion protection, coatings for plastic chemical and fuel containers, and many others.

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260 JSC
91-1-12.12-7947A NAS9-18707
Adaptive, Image-Data Compression for Electronic Still-Photography Systems
Electronic Imagery, Inc.
1300 Park of Commerce Boulevard, Suite 273
Delray Beach, FL 33445
Joseph A. Osborne (407-243-7947)

Data compression software and hardware for compressing megapixel image data for electronic still photography systems will be developed. Appropriate algorithms for low-loss and lossless data compression will be investigated. Feasibility of combining such algorithms to produce the highest level of data compression based on an input parameter specifying the level of acceptable data loss will be determined. Once the feasibility has been established, these algorithms will be modified for use in multiple applications, tested, and incorporated electronically in an off-the-shelf data-compression circuit board chosen on the basis of performance and suitability for easy retrofitting. Phase II will further optimize the algorithms and the modified data-compression circuit board to develop a unique, custom, printed circuit board. A prototype of this custom circuit board will be produced as part of Phase II.

Potential Commercial Applications: Results from the project could allow lossless adaptive compression for storage and transmission of medical high-resolution images such as CAT and PET scans between and among end-users of personal computers. There are also potential applications in high-definition television transmission, digital image network transmission, satellite picture transmission and storage, and video microscopy image storage.

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13: Quality Assurance, Safety, and Check-Out for Ground and Space Organizations

261 KSC
91-1-13.01-0655 NAS10-11854
A Frequency-Tunable, Three-Octave Radar to Monitor Vehicle Exhaust Plumes and Toxic Substances
American Research Corporation of Virginia
P.O. Box 3406
Radford, VA 24143-3406
M.G. Niimura (703-731-0655)

Techniques for sensing electrical characteristics of vehicle exhaust plume and forecasting diffusion of toxic substances are required. This project suggests the use of a frequency-tunable, extremely wideband radar that is operable even during the precipitation period and gives excellent spatial resolution. Neither conventional microwave radar nor lightwave radar (LIDAR) can achieve these two features at the same time. This project's innovation is the use of the multi-frequencies available from a novel high-power radar that measures electrical as well as physical characteristics of the light-emitting (plasma-state) exhaust. The novel radar will be based on the orbitron maser whose frequency is voltage tunable for three-octaves (1 GHz-1 THz). The output power is significantly higher than solid-state sources and multi-channelization is straight forward. The device is rugged, battery-powered, and field-usable, making it suitable for monitoring vehicle exhaust from the liftoff to ascent phases. The Phase I objective is to establish the feasibility of the novel radar as an ionized plume and toxic substances monitor. Anticipated results include correlations between the electrical characteristics of ionized plumes and lightning threat, a multi-channel radar system with pertinent signal processing electronics, and a family of data from simulated plumes and toxic substances.

Potential Commercial Applications: The hand-held, frequency-scannable, rugged radar system will find commercial applications in areas such as airport and harbor surveillance and control; precision geological mapping; traffic safety; remote sensing of clouds, smoke, pollutants, toxic substances, precipitation, and snow and ice thickness; mm-wave scattering; spectroscopy experiments in the laboratory; short-range communication; and NDE of structural integrity.

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262 KSC
91-1-13.01-2621 NAS10-11853
Radar-Determined, Stand-Off Distance for Use in the Launch-Commit Criteria
Aeromet, Inc.
P.O. Box 701767
Tulsa, OK 74170-1767
Ray Harris-Hobbs (918-299-2621)

This project will identify the relationship between the threat of triggered lightning to launch vehicles and radar signatures from convective clouds. The experiment will correlate airborne measurements of electric fields with radar measurements in order to develop radar-derived parameters that will enable the determination of more launch opportunities while maintaining the conservative factor of safety in the launch commit criteria.

Potential Commercial Applications: This work will improve launch opportunities by providing definitive criteria for lightning threat.

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263 KSC
91-1-13.01-5509 NAS10-11857
MUSIC Thunderstorm Location from Spatio-Temporal Electric Field Mill Data
Scientific Applications & Research Associates
15206 Transistor Lane
Huntington Beach, CA 92649
John C. Mosher (714-373-5509)

The Kennedy Space Center is high on the isokeraunic curve (i.e., number of days per year with thunderstorm activities), and this frequency of activity influences all operations. An accurate determination of the distribution and strength of storm cells with respect to their ability to produce triggered lightning is needed. This project will adapt an innovative and proven localization technique that the firm recently developed for applications in electromagnetic source localizations for the brain. This technique, soundly based on multiple signal classification (MUSIC) eigen analysis, will allow scanning in three-dimensional space to search for multiple electromagnetic sources. This technique will significantly enhance the ability to characterize charge distributions in cloud formations in real time and, thus, enhance the ability to determine the probability of triggering lightning with launch vehicles.

Potential Commercial Applications: Safety from lightning effects is of concern to the commercial sector. Use of an accurate storm cell identifier will aid such diverse organizations as commercial airports, construction companies, the U.S. Forestry Service, and golf courses in determining conditions that are appropriate for standard operations.

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264 KSC
91-1-13.03-0202 NAS10-11858
In Situ Measurement of Hydrocarbon Contamination in Precision Aqueous Cleaning
Axiomatics Corporation
3-G Gill Street
Woburn, MA 01801
Francis A. Waldman (617-932-0202)

This project examines the feasibility of a dielectric sensor system to detect and accurately analyze small quantities of hydrocarbon contaminants in water. The system would facilitate efforts to replace freon cleaning of spacecraft parts with precision aqueous cleaning, by providing an in situ method of detecting hydrocarbon contaminants in the part per million range. The sensor technology is based on a shunting dielectric sensor recently invented under a NASA Phase I SBIR project. For this subtopic application, the sensor technology must be improved to provide measurements that are seven orders of magnitude more sensitive than previously attempted, and innovative new software algorithms must be developed to predict ppm-level, hydrocarbon contamination in water. A new sensor that can accomplish these tasks will be developed. The sensor system will provide a unique, in situ capability to validate and potentially control the precision aqueous cleaning process, as well as provide a fast and potentially economical alternative for laboratory use.

Potential Commercial Applications: Potential commercial applications include facilitating replacement of CFC cleaning of semiconductor wafers with water cleaning, on-line detection of hydrocarbons in petrochemical wastes, and water quality analysis.

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265 KSC
91-1-13.03-6239 NAS10-11865
A High-Sensitivity, Real-Time, Non-Volatile Residue Monitor
Femtometrics
1001 West 17th Street, Suite R
Costa Mesa, CA 92627
William D. Bowers (714-722-6239)

The accepted method to measure non-volatile residue (NVR) on payload and orbiter critical surfaces is the use of a one-square-foot witness plate to collect NVR over a period of several weeks. The weight of the solvent-wash residue from the witness plate is reported as NVR mass flux in units of mg/0.1 m^2/month. This method is tedious and time-consuming; it does not give a real-time measurement of NVR originating from activities near the payloads and orbiter. An innovative approach is to measure NVR in real time using a temperature-controlled surface acoustic wave (TCSAW) resonator. The unparalleled stability and high mass sensitivity of the 200 MHz SAW resonator enables NVR measurements down to 6×10^{-5} mg/0.1 m^2 or 0.06 nanograms/cm^2. The high performance of the 200 MHz SAW resonator is realized by comparison to a 10 MHz temperature-controlled quartz crystal microbalance that can measure NVR levels down to 1.3×10^{-2} mg/0.1 m^2 or 13.3 nanograms/cm^2. The 200 MHz TCSAW meets the 0.05 micrograms/cm^2 detection requirement for NVR.

Potential Commercial Applications: A highly sensitive, real-time NVR monitor would be useful in government and industry for monitoring surface contamination during the manufacturing, processing, and storage of payloads, orbiter and space station components, and any other sensitive surfaces in instrumentation and manufacturing processes.

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266 KSC
91-1-13.04-2888 NAS10-11856
Modular Cryogenic Insulation
Aerospace Design & Development, Inc.
P.O. Box 672
Niwot, CO 80544-0672
H.L. Gier (303-530-2888)

Many cryogenic storage vessels utilize powdered insulation materials. When these vessels are filled with cryogens, the pressure vessel contracts, causing the powder to settle and voids to form in the insulation. Subsequent thermal cycling can compress the insulation, leading to decreased thermal performance and possible catastrophic failure of the vessel. Use of multilayer insulation (MLI) in small pieces or contained in packets can provide a high level of insulation, can be retrofittted to existing storage tanks, and will not cause structural failure due to thermal cycling. Due to its resistance to compaction, the MLI will expand to fill the space created by the contracting cryogen vessel, thus preventing the insulation from settling to the bottom of the annulus. Phase I will investigate various methods of packaging the MLI. The ease and cost of manufacturing and retrofitting as well as thermal performance of the various packaging concepts will be compared to determine which are most feasible. From the various methods investigated, two will be chosen for preliminary laboratory thermal performance testing. In Phase II, a preferred MLI concept will be designed, produced, and installed in an existing powder insulated tank.

Potential Commercial Applications: Candidate applications include tank farms at cryogenic production facilities and cryogen transport trailers, as well as end users of cryogens ranging from industry to the scientific and medical communities.

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267 KSC
91-1-13.04-3550 NAS10-11863
Production of High-Purity Liquid Amonia
Mainstream Engineering Corporation
200 Yellow Place
Rockledge, FL 32955-5327
Clyde F. Parrish (407-631-3550)

Phase I will determine the feasibility of using an innovative combination of molecular sieves in the gas phase and then in water solution for the purification of refrigeration-grade ammonia. The purified product will then be compressed to the liquid phase with an oil-less compressor. This will result in a high-purity grade of

liquid ammonia that surpasses the requirement of the current shuttle-grade of anhydrous ammonia (fluid specification SE-S-0073). This project will build a laboratory processing unit and verify its ability to produce high-purity liquid ammonia from refrigeration-grade material. Information gained from Phase I will be used in Phase II to build a pilot-plant-scale production unit at the Kennedy Space Center, sized to meet the current requirements of 3000 lb per year.

Potential Commercial Applications: The firm will be able to market their design for the production of high-purity liquid ammonia. Applications of the design could include small metal-finishing shops.

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268 KSC
91-1-13.05-0200 NAS10-11855
Reliable and Rugged Fiber-Optic Sensors for Detecting Hydrogen Leaks and Hydrogen-Chloride Doses
Optivision, Inc.
4009 Miranda Avenue
Palo Alto, CA 94304
Behzad Moslehi (415-855-0200)

The use of porous fiber-optic sensor technology for application to real-time and passive detection of hydrogen gas leaks and hydrogen chloride doses is proposed. This generic sensor design can be optimized for sensing diverse chemicals. Porous fibers have a large surface sensing area composed of many interconnected submicron pores that are created by a thermal-chemical leaching process applied to a small section of conventional fiber. The pores are coated with a chemical indicator having an optical absorption proportional to the concentration of the chemical to be sensed. Chemical diffusing through the pores alters the spectral transmittance of the porous region which can be measured with an optical source of proper wavelength and a photodetector. This in-line fiber design yields an extremely sensitive sensor in a compact package. Technological and economic evaluations will be performed in Phase I to determine the performance and cost-saving capabilities. A breadboard fiber-optic chemical sensor will be designed, constructed, and evaluated for sensitivity and reliability. Characteristics of porous technology include lightweight, ruggedness, accuracy, reliability, low cost, reversibility, fast response, multiplexing, remote sensing and localization capabilities, and compactness.

Potential Commercial Applications: Fiber-optic chemical sensors have the potential to offer superior sensitivity, reliability and lower cost than is offered by conventional electrochemical approaches. Commercial applications include chemical instrumentations, oil plants, semiconductor manufacturing, utilities, environmental sensing, and biochemistry.

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269 KSC
91-1-13.05-8899 NAS10-11859
Real-Time Detection of Hydrogen and Other Atmospheric Gases
Analytica of Branford, Inc.
29 Business Park Drive
Branford, CT 06405
Erol E. Gulcicek (203-488-8899)

A novel mass spectrometry technique will be developed for use as a real-time gas leak detection system in NASA field operations. It will detect continuously and simultaneously hydrogen and other atmospheric gases in very low ppm concentrations. It will be compact and operational under harsh environmental conditions. Depending on the operating mode of the instrument and the input conditions of the sample gas, the response times are expected to be in the range of 10 microseconds to 100 milliseconds at sample pressures ranging from above atmospheric to high vacuum. The goal of Phase I is to develop a real-time, direct and low-cost detection system for many atmospheric gases. Previous experiments performed with a similar instrument indicate that a detection sensitivity of 50 ppm should be routine and below 10 ppm for any gas should be within reach of the proposed technique. Phase I will experimentally verify this new technique and will establish the exact limitations of the instrument performance for measuring hydrogen and other gases. Quantitative measurements of minimum detection levels, precise response times, repeatability, linearity of detection range, temporal drift, background, and memory effects will be determined.

Potential Commercial Applications: If this instrument proves viable, its operational simplicity, compactness, mobility, and adaptability to a wide range of pressures and environmental conditions will be superior to any of the current residual gas analysis techniques.

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270 KSC
91-1-13.05-9040 NAS10-11862
Miniature, Ruggedized Mass Spectrometer
Schmidt Instruments, Inc.
2476 Bolsover, Suite 234
Houston, TX 77005
Howard K. Schmidt (713-529-9040)

A need exists to rapidly detect, identify, and possibly respond to working fluid leaks from spacecraft, both in flight and on the ground. Mass spectrometry (MS) provides the most chemically general means of leak detection. MS-based residual gas analyzers (RGAs) are commonly used in the laboratory and on vacuum installations; however, they have almost no penetration into applications requiring portability and extreme reliability. In general, mass spectrometers are large and delicate instruments. However, the time-of-flight mass spectrometers (TOF-MS) are extremely simple, and experience suggests that a TOF-MS may provide an

affordable solution to leak detection problems. Therefore, the objective in Phase I is to construct, characterize and test a breadboard-level atmospheric sampling miniature, ruggedized mass spectrometer (MRMS). If successful, this would provide the foundation for constructing prototype and preproduction-level field versions of the MRMS for on-site testing at a NASA facility.

Potential Commercial Applications: Commercial laboratory applications for mass spectrometers in analytical chemistry are well known. Small, robust instruments would permit real-time characterization of materials in the field, and make continual, autonomous MS-based leak detection possible.

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271 JSC
91-1-13.07-5668 NAS09-18675
High-Sensitivity Hydrazine and Nitrogen-Tetroxide Detector System
TPL, Inc.
3754 Hawkins NE
Albuquerque, NM 87109
Tim Tiernan (505-345-5668)

A portable, extremely accurate hydrazine and nitrogen-tetroxide detector system will be developed. The sensor is based upon a surface acoustic wave (SAW) device. SAW devices have demonstrated extreme sensitivity to mass changes (pg/cm^2)--a capability that theoretically allows less-than-ppb measurement accuracy for gas phase species. Development of the SAW device with a well-bonded, thin-polymer film that is highly selective to hydrazine and its derivatives or to nitrogen tetroxide will allow rapid measurements with an accuracy of parts per billion. These devices require little power to operate and can be further miniaturized using advanced technology for patterning the transducers. The research can also be applied to a variety of other sensors by modifying the derivatized surface to form complexes with different species such as HCl, C0, volatile organics, etc.

Potential Commercial Applications: A successful capability to measure hydrazines can be made applicable to a range of toxic species by changing the SAW surface.

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272 KSC
91-1-13.09-0056 NAS10-11864
High-Frequency, Magneto-Optic Eddy-Current Imager for the Detection of Shallow Cracks
Physical Research, Inc.
25500 Hawthorne Boulevard, Suite 2300
Torrance, CA 90505-6828
David Thome (310-378-0056)

The purpose of this project is to improve substantially the capabilities of magneto-optic eddy-current imaging (MOI) technology. This technology has recently been developed for rapid inspection of surface breaking cracks near rivets and second-layer cracking and corrosion in aluminum aircraft alloys. Commercial MOI instruments, geared to the evaluation of aging aircraft, are now available and are suitable for the rapid inspection of large, relatively flat surfaces. They are also useful for directly imaging residual or induced magnetic fields in ferromagnetic materials, but are presently limited to excitation frequencies of 100 kHz or less. Recent testing of graphite composite honeycomb material bonded to an aluminum core also showed very promising results for imaging and detection of delaminations. The technology offers the advantages of rapid inspection, direct imaging, improved data presentation, and greater sensitivity to detection of small surface cracks, such as those emanating from rivets. There is a need to extend the range of these instruments for inspection of more complex shaped components, using higher frequencies to detect and image shallow, tight surface cracks. This may allow eventual replacement of present dye penetrant inspection techniques.

Potential Commercial Applications: Development of magneto-optic, eddy-current imaging technology at higher frequencies and power levels will open the door for use on titanium alloys and the rapid detection of small, shallow, surface-breaking fatigue cracks, allowing better discrimination between actual cracks and surface scratches. Non-destructive inspection will thus be improved in the aerospace industry for both production and in-service evaluation.

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273 MSFC
91-1-13.10-0175 NAS08-39309
Automated Visual Inspection of Rocket Engines
Chandler/May, Inc.
150 West Park Loop
Huntsville, AL 35806
K.S. Henry (205-722-0175)

In this project, the approach is to use new technology in designing an automated inspection system for various hardware components of reusable rocket engines. To be successful, the system must be able to detect flaws with greater reliability than manual inspection techniques. Innovative methods and techniques for performing image acquisition and image processing functions for the identification and classification of engine flaws will be investigated. Revolutionary technologies will be incorporated into the design of an inspection system to facilitate functions such as image acquisition, image sensor placement, and image processing, storage, and retrieval. Recent innovations in image processing hardware and software can be used to perform processing such as edge detection, feature list extraction, image segmentation, and morphological operations in real-time, resulting in significant improvements over the current inspection process for automatically detecting and analyzing flaws. The inspection system will utilize state-of-the-art technologies for

performing the inspection process resulting in improved accuracy, resolution, repeatability, and documentation of engine-defect measurements.

Potential Commercial Applications: Applications could be found in automated visual inspection in machine shops and fabrication facilities for performance of tolerance and integrity checks of manufactured parts. Another potential use is automated circuit board inspection during the manufacturing process. Automated visual inspection systems could be utilized to check for proper component placement and part number.

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274 KSC
91-1-13.11-1946 NAS10-11866
Pultruded Structural Composites Having High Flammability Resistance and Electrical Conductivity
Largo Scientific, Inc.
9430 Ulmerton Road, East
Largo, FL 34641
Richard Kent Spears (813-581-1946)

This innovation will develop nonmetallic composites for use in missile launch facilities. The objective of this project is to formulate a composite that will meet the NASA launch environment requirements and can be produced by the pultrusion process. Through an extensive series of tests on numerous laboratory fabricated composites, a single composite for Phase II is desired. Materials to be examined are heat-resistant resins, various fibers, conductive fillers and veils to dissipate charge, and additives to retard flame and to prevent photolytic degradation. An initial study characterizing neat resin properties will examine propellant compatibility, flammability, and pultrusion processibility. Then simulated pultruded composites will be fabricated using high-pressure RTM processing. This operation is vital to the success of the program since it will conserve material and provide numerous composite test specimens of varying compositions. Thermoset resins consisting of phenolic, novalac-triazine, cyanates, BMI, and toughened epoxies will be evaluated using S-glass and Kevlar fibers. Conductive fillers or carbon veils will dissipate charge. Preliminary design criteria, galvanic corrosion, and the overall economics will be examined. This study will provide NASA with valuable state-of-the-art information on high-performance pultrusions suitable for launch facilities.

Potential Commercial Applications: The technology can be applied in missile launch facilities, offshore drilling operations, and the chemical industry. Of particular interest is the aircraft industry where the need for tough, flame-safe materials is needed.

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275 SSC
91-1-13.12-2101 NAS13-486
Active Corrosion Analysis
Texas Medical Electronics Company
P.O. Box 35725
Houston, TX 77235
Hayati Balkanli (713-728-2101)

The goal of this project is to provide a method to characterize cathodic protection systems by injecting active signals into a test point instead of interrupting the impressed current. This method, which observes the response of the system to an active signal, will determine parameters that could not be measured before. In addition to the IR-drop and polarized potential, the other parameters that can be measured are the equivalent resistance, the rise times of the wave-forms generated by the active signals, depletion-region capacitance, painting capacitance, the decay time of polarized potential, and delineation of the corrosion-accelerating potentials and normal potentials. The project objectives include the implementation of the active signal generating circuits and the measurements of said parameters in addition to the actual proof-of-concept and evaluation of the ion distribution under the effects of the interfering fields. Phase I will be concentrated on measuring the above parameters in addition to the proof of the existence of said parameters in a simulated condition. NASA will be able to protect its corroding structures with a minimum of cost and effort through electrolysis and active analysis.

Potential Commercial Applications: Commercial application exists in the cathodic protection of buried pipelines, storage tanks, and offshore platforms.

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276 SSC
91-1-13.13-3113 NAS13-480
Optical Pavement Profile Scanner
Integrated Technologies, Inc.
210 South Beach Boulevard
Bay Street Louis, MS 39520
Charles B. Dickinson (601-466-3113)

Phase I examines the problem of manual data gathering and tedious evaluation by engineering personnel needed to provide the inputs to existing pavement management programs. Optical methods developed for welding research applications will be adapted for the gathering of the physical data on the condition of the paved surface. Artificial intelligence programs will be developed to provide the evaluation of the surface and the conversion of the evaluation to pavement condition index values that can input to programs such as PAVER.

Potential Commercial Applications: City, state, and federal agencies charged with the maintenance of highway, roads, and airports would find immediate use in such a device. Also, the data could be stored and

later used to determine the effectiveness of the maintenance procedures.

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277 SSC
91-1-13.13-3970 NAS13-487
Rapid Pavement Surveying and Data Management
Thermalscan, Inc.
Business & Technology Center,
South Stadium Drive
Baton Rouge, LA 70803-6100
James E. Davidson (504-388-3970)

Infrared thermography, video imaging, global positioning, frame capture digitization will be incorporated with an automated pavements management computer program to perform innovative, rapid, pavement surveying and data logging. Infrared thermography is a viable means to survey pavements rapidly; however the images are normally from video recordings and not digitized into a computer software image-management format. As an additional innovation, global positioning satellites will be used to identify the location of distressed areas with at least 30 cm accuracy. The distressed areas will be categorized and all data will be collected on computer and linked to a developed engineered pavements management program. Currently, pavement condition data is collected by manual and visual means. This new method will benefit NASA by providing a rapid and accurate method of locating, categorizing, and prioritizing distressed areas, both visible and nonvisible,for maintenance purposes. The savings in labor, time, maintenance, and repair costs will be substantial.

Potential Commercial Applications: Broad potential applications would include inspection and maintenance of paved roads, bridges, aircraft runways, parking areas, and industrial and military facilities.

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278 SSC
91-1-13.14-3550 NAS13-484
An Innovative Approach for Solvent Selection
Mainstream Engineering Corporation
200 Yellow Place
Rockledge, FL 32955-5327
Clyde F. Parrish (407-631-3550)

An innovative method for selection of a solvent, based on molecular structural properties, is the objective of this project. Phase I is directed specifically to the selection of solvents for cleaning and flushing piping components in gaseous and liquid oxygen service associated with propulsion testing. This innovative method is based on the use of a software package, ADAPT (automatic data analysis using pattern recognition techniques), that correlates physical and chemical properties of molecules with their structural properties. ADAPT uses pattern-recognition methods to develop structural-activity relations (SARs) that are based on numerically encoded structural features. These SARs are used to develop regression equations that can be used to quantitatively predict properties of compounds where no data exist. This will allow examination of a large number of compounds for which insufficient data exist for selection of a freon replacement. This screening approach is much faster than laboratory techniques. A database of information on all solvents studied in this investigation, the descriptors that define the data set, and the regression models obtained form the ADAPT program that can project properties similar to freons will be provided. Completion of this effort will result in replacement solvents for freons and a regression model that could be used to select replacements for other freons.

Potential Commercial Applications: Development of ADAPT and the data sets for CFCs, HCFCs, and perfluorocarbons will have many commercial applications for industrial cleaning applications beyond the printed circuit board industry and heat-transfer working fluid applications.

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14: Satellite and Space Systems Communications

279 JSC
91-1-14.01-1950 NAS9-18668
Digital Communication System Integration
Shason Microwave
P.O. Box 580488
Houston, TX 77058
R. David Sanderlin (713-333-1950)

An innovative packaging concept to implement a high-speed digital/microwave modem will be developed. It leverages recent advances in ECL and GaAs digital modulators and demodulators, combined with MMIC technology, to yield a small size, low-weight, integrated system that maximizes receiver sensitivity, data rates (> 50 Mbps), flexibility to support multiple modulation modes, and configurability. The objective is to define an architecture suitable for implementation in Phase II that addresses data rates, modulation-mode support, up- and down-conversion, millimeter-wave power and low-noise amplification, and overall integration. A digital, microwave modem would be applicable to a variety of communication systems utilized by NASA. Telerobotic control and the ACTS program are two examples.

Potential Commercial Applications: An integrated digital, microwave communication modem would apply to any communication system that requires high data rates. The VSAT, DBS, terrestrial digital radio, and

satellite video markets are all examples of potential commercial application.

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280 JSC
91-1-14.01-8933 NAS9-18679
Ferroelectric Liquid Crystal Printhead
Displaytech, Inc.
2200 Central Avenue
Boulder, CO 80301
Mark A. Handschy (303-449-8933)

A linear array of light sources that can be individually switched with low-voltage, low-power electrical signals will be developed. The approach will be to fabricate a linear array of pixels using ferroelectric liquid crystals (FLC) that act as shutters for a separate, unswitched light source. These fast-switching liquid crystals (50μs at 15 volts dc drive) can be pixelated with standard photolithographic techniques to produce densities up to 500 pixels/inch for transmissive-mode and up to 4000 pixels/inch for reflective-mode devices. For a long transmissive-mode device, utilization of chip-on-glass technology or tape automated bonding will allow the driving electronics to be mounted on the glass substrate used for the pixel electrodes, simplifying the electrical interface. For a miniaturized reflective-mode device, implementation of a hybrid spatial light modulator consisting of an FLC-layer coupled with a VLSI silicon integrated circuit will eliminate the need for complicated electronic interconnects. In either case, grey scale operation can be obtained by using a novel analog FLC material or time-resolved addressing methods, and the use of color filters would make full-color output feasible. Phase I will determine which linear array approach is most feasible, demonstrate grey scale operation, and consider the options for creating color hardcopy.

Potential Commercial Applications: A linear array of 4096 individual light sources, with opportunity for both grey scale and color operation, could be used to produce scanned, two-dimensional displays for instrument panels, interactive terminals, and consoles. A specialized FLC/VLSI hybrid array could also be used for a scanned two-dimensional private eye head mount display. The FLC linear array would find use as the exposure unit in electrophotographic printing.

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281 GSFC
91-1-14.02-2250 NAS5-31882
Automatic Co-Alignment of Multiple Diode Laser Beams
Laser Data Technology, Inc.
9375 Dielman Industrial Drive
St. Louis, MO 63132
Ernest Clarke (314-997-2250)

Techniques will be explored which enable multiple diode lasers to remain co-aligned at the output of a diode laser beam combiner by means of active automatic feedback. These innovations employ designs for minimal power, size, and weight appropriate to space-borne diode laser transmitters. The project objectives are to design and evaluate a number of potential concepts from which the most promising will be selected. Thermal, piezoelectric, magnetic, and magnetostrictive concepts are evaluated on the sensitivity and range of control needed with minimal size, weight and power. The results will enable successful development of a practical co-alignment implementation and provide significant benefit in ensuring long-term operation of space optical links. Diode laser transmitters require the combining of multiple diode lasers from moderate and high data rate links. Successful results would eliminate the risk of long-term misalignment and improve link viability.

Potential Commercial Applications: There are a number of industrial-medical applications that can make use of automatic co-alignment of multiple diode lasers where they are used to form high-power diode laser beams for industrial trimming, cutting, and surgery.

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282 JPL
91-1-14.03-0700 NAS7-1174
Frequency-Stabilized, Microlaser Local Oscillator
Laser Power Corporation
12777 High Bluff Drive
San Diego, CA 92130
Timothy Boyd (619-755-0700)

Presently, there is a need for a substantial increase in the data rate available for deep space communications over that afforded by present microwave technology, which provides only a few tens of kilobits per second. By means of advanced microlaser technology, optical communications data rates on the order of 100 megabits per second are foreseeable. The concept incorporates a diode-pumped microlaser to fulfill the associated need for frequency stable local oscillators. An electro-optically tunable monolithic microlaser allows fast control of the cavity resonance frequency. Thus the frequency can be tuned or scanned by applying a voltage to the laser. This technology offers the potential for extremely frequency stable, compact, low-cost, local oscillators and represents a substantial improvement over the current state-of-the-art non-planar monolithic lasers. Two approaches are addressed: an electro-optic, frequency-tunable microlaser of less than 5 kHz linewidth, suitable for deep space deployment, and an actively stabilized microlaser of extreme frequency stability, suitable for ground based applications. Phase I includes a proof-of-principle experiment designed to generate a narrow linewidth, frequency tunable microlaser, as well as a survey to identify optimal materials for microlasers.

Potential Commercial Applications: This microlaser will provide compact, inexpensive sources with potential applications including operation as stable, single frequency injection-seeders for master-slave oscillator systems, tunable narrowband sources for precision spectroscopy, and as a local oscillator source for coherent heterodyne detection systems. Arrays of this microlaser hold the promise for high power cw, electronically steerable systems, for utilization in parallel optical processing.

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283 JPL
91-1-14.03-6000 NAS7-1161
Monolithic, Integrated, Heterodyne-Receiver Chip
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
H. Paul Maruska (617-275-6000)

A monolithically integrated semiconductor chip containing a tunable diode laser, channel waveguides, and a tandem set of dual detectors will be developed to function as the front end for a heterodyne communications receiver for deep space exploration applications. The material of choice will be GaAs/AlGaAs, to match the wavelength of the highest power diode laser presently available. The laser will serve as local oscillator, to be mixed in the two-channel waveguide with the incident optical signal flux. Phase I will concentrate on the design and implementation of the detector pair and associated waveguides. The detectors must be connected in series electrically to take advantage of the available 3 dB increase in signal intensity and cancellation of excess diode laser noise. An unconventional growth sequence will be followed, whereby one detector will be positioned above the other; coupling from the lower to the upper waveguide will be provided by a set of distributed Bragg gratings. The design of these gratings will allow complete lightwave transfer will be a major concentration of effort. Phase II will be the design of an advanced tunable laser and the total integration of the complete structure.

Potential Commercial Applications: A functional heterodyne receiver chip can find extensive commercial use as the front end for fiber systems delivering home entertainment to the public.

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284 LeRC
91-1-14.05-0333 NAS3-26392
Silicon-Germanium-Heterostructure, Bipolar Transistors
Scientific Research Associates, Inc.
P.O. Box 1058
Glastonbury, CT 06033
Harold L. Grubin (203-659-0333)

This project addresses the design and fabrication of Si-GE heterostructure bipolar transistors (HBT) for applications in communications. Emphasis will be placed on low-noise, high-power and high-frequency performance. The innovation here is the use of an advanced, device-physics-simulation computer code for the design of the devices. Devices will be fabricated according to the design emerging from the analysis because it will be more cost-effective and eliminate the trial-error effort normally employed in fabrication procedures. The numerical simulation procedure has been well tested in the design of AlGaAs/GaAs HBTs, InGaAs/InP HBTs, HEMTs, and PBTs.

Potential Commercial Applications: Si-Ge HBTs have significant promises for high-speed circuits. There is a significant commercial potential for the devices and analysis computer code.

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285 LeRC
91-1-14.05-9392 NAS3-26390
A Distributed, Menu-Driven Software Tool for the Design of Traveling Wave Tubes
Analatom, Inc.
1183 Bordeaux Drive, #1
Sunnyvale, CA 94089
Wolfgang Mueller (408-734-9392)

A software package will be developed for the design of traveling wave tubes (TWT) . The package integrates a menu-driven, a graphical user interface, advanced networking, and distributed processing among workstations and supercomputers in a single application. This computational tool is geared toward the R&D engineer, with particular emphasis on space communications applications. Phase I will concentrate on codes modeling the interaction between the electron beam and radio-frequency fields in helical and coupled-cavity TWTs. Provisions will be made to include additional codes for electron gun and collector design in Phase II, such that complete device simulations will become available. The efficiency of existing codes will be enhanced by code-specific vectorization, optimization, and parallel-processing techniques. Advanced numerical techniques from the environment of computational fluid dynamics research and present modeling capabilities will be further refined. The final product will be an efficient, user-friendly, interactive computational tool that will dramatically improve the TWT simulation process and thereby reduce the development time and cost for advanced electron devices.

Potential Commercial Applications: Traveling wave tubes are major components in satellites for near-earth and deep-space communications, high-resolution radar systems for air traffic control and weather forecasting, microwave power transmission devices, and microwave instrumentation. The developed tool would be used by

the design engineer for device optimization before hardware implementation.

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286 LeRC
91-1-14.06-4406 NAS3-26391
Optimum Phase Demodulation and Adaptive Channel Equalization with Hopfield Neural Networks
Chirp Corporation
8248 Sugarman Drive
La Jolla, CA 92037
Richard A. Altes (619-453-4406)

Hopfield networks can be applied to adaptive filtering and to fast, iterative solution of certain nonlinear integral equations. Adaptive filtering capability can be used for equalization of time varying communication channels, and nonlinear equation solving can be applied to optimum demodulation of phase coded signals. Both of these applications are relevant to the problem of demodulating M-ary phase-shift-keyed satellite communication signals subject to channel noise and fading. Phase I will use software simulations of Hopfield-based and more conventional receivers to verify the theoretical advantages of Hopfield networks for performing adaptive channel equalization and optimum phase demodulation, and to better define future hardware implementations via working software simulations. Phase I, if successful, will justify a Phase II investment in building hardware implementations to improve satellite and space communication capability. The innovation that forms the basis of the proposed work is an efficient implementation of maximum a posteriori phase demodulation with a VLSI analog neural network. This innovation allows real-time optimum reception or angle-modulated communication signals for the first time.

Potential Commercial Applications: A VLSI implementation of the Hopfield network will replace phase-locked loop demodulators with ones that are truly optimum and hence yield better performance in FM radios, television, and communications systems. Applications in consumer electronics and communications are widespread.

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287 LeRC
91-1-14.06-7733 NAS3-25935
Algorithm for Video Data Compression Based on Improved Moving Picture Experts Group
Space Computer Corporation
2800 Olympic Boulevard, Suite 104
Santa Monica, CA 90404-4119
William B. Kendall (213-829-7733)

Efficient compression of image sequence data is a limiting technology for many digital video transmission and storage systems. Emerging video compression techniques such as those based on the preliminary moving picture experts group (MPEG) standard cannot consistently achieve maximum performance because they utilize fixed image partitions and simple motion compensation algorithms. Significantly higher compression ratios will be obtained by using the video compression approach based on adaptive sub-pixel motion prediction and multi-resolution image representations. These enhancements result in two-fold or greater reductions in the number of bits required to encode the prediction error and the motion description--the two major components of the MPEG inter-frame transmission. Phase I will integrate sub-pixel motion prediction and multi-resolution descriptions within the framework of the emerging MPEG video compression protocol, and will develop a software tool for off-line testing on actual video data. Phase II will refine and select a final set of video compression algorithms, and investigate their implementation in special-purpose VLSI hardware.

Potential Commercial Applications: There would be markets in digital high-definition television, video conferencing, video telephone, video training, video surveillance, video games, and video archiving.

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288 LeRC
91-1-14.07-8551B NAS3-26389
A Flat, Dual-Band Array at 20 and 30 Gigahertz for Small-User Communication Terminals
Millitech Corporation
South Deerfield Research Park, P.O. Box 109
South Deerfield, MA 01373
Howard Y. Jong (413-665-8551)

A compact, lightweight and mass-producible, low-cost, flat, dual-band array antenna will be developed. The antenna architecture is a multilayer, passive, planar array at 20 GHz and 30 GHz. The array antenna consists of electromagnetically coupled elements. A dual-frequency slot microstrip disc-tab and a circular polarized slot element will be considered for the array.

Potential Commercial Applications: The flat dual-band array antenna can be used on small-user communication terminals to function with the advanced communications technology satellite (ACTS) that can provide diversified services, instant access to data bases, and intersystem connectivity.

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289 JPL
91-1-14.08-4001 NAS7-1182
Ka-Band Antennas for Personal Communications
Frederick Herold & Associates, Inc.
7303A Hanover Parkway
Greenbelt, MD 20770
Julius A. Kaiser (301-982-4001)

This project outlines an approach to obtaining high-gain directive tracking antennas at 20 and 30 GHz for ground terminal applications. Signal conditioning to

augment self-phasing of the transmit/receive beams from planar arrays is described in order to provide insight to this innovative and unique design approach which utilizes spatial frequency technology for its basis. The handheld system automatically acquires and tracks a satellite over a hemisphere.

Potential Commercial Applications: The use of phased-array technology with handheld personal communications devices should have future significance in the telecommunications industry with the introduction of the IRIDIUM system and with the increasing use of the wireless telephone. The antenna and satellite interface will be the key to personal communicator technology in the future.

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290 JPL
91-1-14.08-6076 NAS7-1178
Novel, Moldable Antenna Concept for Personal Communications
UBC, Inc.
8405-A Benjamin Road
Tampa, FL 33634-1205
Mark T. Moczynski (813-884-6076)

The goal of this project is to design and implement a moldable antenna concept for 20 and 30 GHz personal communications. Using the concepts of a solid body antenna and PLASTEK componentry, a compact, rugged, high-performance, low-cost antenna assembly can be demonstrated. These technologies are diverse, permitting pencil beam or monopulse patterns, polarization diversity, etc. Specific objectives include study of dual-frequency feed implementations, generation of circular polarization, development of a baseline design, fabrication and test of a deliverable breadboard assembly, and generation of a technical report summarizing activities. The hardware evaluation will quantify accuracy of the design process and demonstrate the feasibility of the concept in meeting established performance goals. Near-term benefits include the low cost implementation of a novel antenna system for personal communication with long-term potential integration of the transmitter and receiver into the antenna system.

Potential Commercial Applications: These techniques offer a wide range of potential applications, both commercial and military. They can be employed in most any system requiring compact, high-performance, low-cost components such as in personal satellite communications and police radar front ends. Military applications include terminal homing sensors and portable communication systems.

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15: Materials Processing, Micro-Gravity, and Commercial Applications in Space

291 MSFC
91-1-15.01-2043 NAS8-39332
High-Field, Low-Mass, Permanent Magnet and Shielding for Applications in Space
Microgravity Systems, Inc.
4215 Highway 72 East
Brownsboro, AL 35741
Bill R. Aldrich (205-776-2043)

The process of melt growth of semiconductor crystals under low-gravity environment provides the commercial potential for the growth of compositional homogeneous and defect-free crystals. Residual accelerations on orbiting spacecraft cause convective motions and affect the quality of the grown crystals. The Lorentz force, induced by a magnetic field when the melt is electrically conductive, can decrease the intensity of cellular, buoyancy-driven convection. The unique condition of combining a low-gravity environment and a magnetic field will be performed by constructing a magnetic field flight apparatus. Phase I will design, fabricate, and test a cylindrical permanent magnet that can provide an axial field up to 2000 gauss for the growth furnace that lies coaxially inside. A magnetic field shielding system for the permanent magnet to shield stray magnetic fields will also be developed, fabricated and tested.

Potential Commercial Applications: It is anticipated that crystals of the best quality in both structural and homogeneous aspects will be processed for the magnet growth apparatus in an orbiting spacecraft. The size and design of this furnace system will provide a means to perform rapid quench or casting experiments under low gravity conditions either using KC-135 low-gravity flight or sounding rockets.

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292 MSFC
91-1-15.01-3184 NAS8-39308
Space Processing of Biopolymers for Nonlinear Optical Applications
Cambridge Scientific, Inc.
195 Common Street
Belmont, MA 02178
Debra J. Trantolo (617-484-3184)

Defect-free crystals that exhibit optical nonlinearities are of great interest. Recent development of polymers with large second- and third-order nonlinear effects has generated interest in the potential of polymeric nonlinear optical materials (NLOM). The ideal NLOM would have a large nonlinear response, extremely low switching thresholds, and rapid switching times, as well as amenability to defect-free fabrication. Crystals grown in space have been shown to be of higher quality than

Earth-grown crystals because more defect-free specimens are obtained in the absence of gravity-driven convection. Defect-free organic crystals are of interest because they can exhibit high optical nonlinearities. However, they tend to be brittle and cannot be as easily fabricated into thin films or fibers as can polymer analogs. The synthesis and fabrication of polymeric material for NLO is currently an active area of research. However, little attention has been paid to the growth of high-quality macromolecular films and/or fibers in space. It is envisioned that polymers having a controlled supermolecular structure and morphology could be even more promising candidates as NLOM. Phase I will establish the feasibility of processing biopolymers, materials with known supramolecular structure, under zero-gravity conditions in order to optimize optical nonlinearity effects. The particular importance of understanding polymer-processing conditions as well as new biopolymeric structures will be identified.

Potential Commercial Applications: NLO materials have broad applications in opto-electronic interconnects, spatial light modulators in optical computing systems, memory storage systems, and protection of visual sensors. These applications are of immediate interest to NASA, telecommunications industries, and advanced knowledge-based systems.

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293 MSFC
91-1-15.01-6551 NAS8-39345
Moving-Temperature-Gradient, Heat-Pipe Furnace Element for Low-Gravity Crystal Growth
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
Nelson J. Gernert (717-569-6551)

This innovation is a single element furnace for implementing directional solification by the Bridgeman method. The furnace generates a moving thermal gradient by expanding a non-condensible gas in a heat pipe furnace liner. The non-condensible gas is used to block the flow of hot heat-pipe working fluid to that region, thus creating the gradient. This furnace concept is completely static. The crystal and the furnace remain in fixed positions during the growth process. Since there is no motion involved, the furnace is compact. It also will help reduce vibrations that have an adverse effect on the growth process. The objective of Phase I is to demonstrate the feasibility of a moving gradient heat-pipe furnace (MGHPF) for material processing in space. Feasibility will be demonstrated through the design, fabrication, and testing of a furnace element.

Potential Commercial Applications: The variable temperature gradient heat-pipe furnace element could offer significant advancement to materials processing on earth or in space. It could be used for Czochralski and Bridgeman crystal growth methods since control and operation of the furnace would be greatly simplified and the versatility of the growth system increased.

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294 LeRC
91-1-15.01-7200 NAS3-26505
Zinc-Telluride: Vanadium for Optical Information Processing in the Wavelengh Range 0.6 Microns to 1.3 Microns
Brimrose Corporation of America
5020 Campbell Boulevard
Baltimore, MD 21236
S.B. Trivedi (301-931-7200)

This project will produce a novel photorefractive material, vanadium-doped zinc telluride (ZnTe:V). It has photorefractive sensitivity in the wavelength range 0.6μm- to-1.3μm, which covers important coherent optical communication wavelengths. Its photorefractive sensitivity range is compatible with existing low-power semiconductor laser wavelength range, makeing it important for optical information processing applications. However, application-grade crystals of ZnTe:V are very difficult to grow and are commercially unavailable. Phase I will grow ZnTe:V crystals using physical vapor transport and travelling heater methods. Material processing using both these techniques involves fluid flow and is effected by buoyancy-driven convection. This approach will have dual accomplishments: production of novel photorefractive materials, and understanding of gravity-induced convection on the quality of this material.

Potential Commercial Applications: The project will result in a superior photorefractive material useful for optical information processing and for such opto-electronic devices as spatial light modulators, optical limiters, differential amplifiers, and optical switches operating at visible and near infrared wavelength.

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295 LeRC
91-1-15.02-0204 NAS3-26545
Spatial, Infrared, Spectral Sensor for Micro-Gravity Combustion Experiments
Sensor Systems Group, Inc.
150 Bear Hill Road
Waltham, MA 02154
Wallace K. Wong (617-890-0204)

The design and development of an instrument for the non-perturbing measurement of source gases, combustion products, and heat flow in combustion experiments in a microgravity environment will be explored. The innovation is an imaging spectrometer using all reflective optics, problem-specific dispersive elements, and commercially available focal plane arrays (FPA). The imaging spectrometer provides spatial and temporal information in the form of IR imagery with each spatial pixel having a complete spectrum with good spectral

resolution. The use of all reflective optics allows the spectrometer section of the instrument to be tailored to various spectral bands by proper choice of the FPA and the disperser. Multiple bands may be covered by using multiple spectrometers fed by dichroic beam splitters. The spatial, temporal, and spectral data can be presented in several different ways to suit experimental objectives. A preliminary design of a ground-based sensor will be developed which will be capable of being upgraded to air-borne and space-borne service. Future development will provide low-cost imaging spectrometers through the use of low-cost reflective optics, commercial focal plane arrays, and signal-processing electronics. A breadboard demonstration of an imaging spectrometer will be developed.

Potential Commercial Applications: Commercial applications include shuttle, aircraft, and space station microgravity experiments; rocket combustion analysis device; general combustion monitor device for aircraft, and automobiles.

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296 LeRC
91-1-15.02-3800 NAS3-26542
Non-Disturbing, Gas-Fraction Meter for Two-Phase Flows in Microgravity

Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Christopher J. Crowley (603-643-3800)

Two-phase thermal management systems (TMS) and power systems are being developed for spacecraft because their isothermality and low pressure drop characteristics lead to significant savings in mass. However, a measurement of gas fraction (or quality) is needed in order to understand crucial two-phase flow transients in these systems, to control the system during operational transients, and to understand and model steady two-phase flow behavior in microgravity. This need has been apparent during developmental testing of several systems, including Air Force-sponsored research with a unique two-phase system concept aboard a KC-135 and the pending "STARS Rocket" microgravity experiment. No instrument presently exists to meet the need for spacecraft applications. A rugged, reliable instrument based on the capacitance-measurement approach will be developed. An innovative geometric design of the sensor and design of high-sensitivity electronics can provide an instrument which can measure transient gas fraction for fluids of interest under spacecraft microgravity conditions.

Potential Commercial Applications: This instrument will benefit NASA, the Air Force, and aerospace contractors, enabling confident design of advanced two-phase systems via measurement of transient fluid distributions that are crucial to design and operation.

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297 LaRC
91-1-15.03-3800 NAS1-19523
Computation Simulation Methods for Particle Nucleation, Growth, and Transport During Chemical Vapor Deposition

Creare, Inc.
P.O. Box 71
Hanover, NH 03755
James J. Barry (603-643-3800)

The quality of thin films grown by chemical vapor deposition (CVD) will be improved by effectively utilizing the microgravity environment of space. Numerical modelling tools that can predict important CVD process behavior would accelerate this improvement through comparison of theory with Earth-based testing and early identification of systems and processes for which costly space experimentation is warranted. An especially important phenomenon in CVD, due to its usually detrimental impact on film quality, is particle formation and growth in the precursor gas mixture. This project addresses the development of an innovative numerical modelling tool to predict nucleation and subsequent growth of particles during CVD. The approach is based on a computational fluid dynamics computer program called FLUENT developed to stimulate many phenomena of interest to CVD. Phase I consists of implementing models for particle nucleation and growth in order to demonstrate that FLUENT is a suitable framework for general purpose modeling. Verification will be provided by comparison of results with previous work from the literature. If results are favorable, the models will be generalized during Phase II, yielding software for use by NASA scientists and others.

Potential Commercial Applications: Uses include improved design of hardware by semiconductor equipment manufacturers and optimum choice of process parameters for CVD hardware users. Other technology areas to benefit include: CVD of thin films for optics; combustion with sooty flames; mitigating the fouling in heat exchangers; and formation of preforms for optical fibers using modified CVD.

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298 LeRC
91-1-15.05-1772 NAS3-26574
High-Temperature, Containerless, Thermophysical Property Measurements in Microgravity

Intersonics, Inc.
3453 Commercial Avenue
Northbrook, IL 60062
J.K. Richard Weber (708-272-1772)

Predictive modeling of industrial processes such as casting, crystal growth, and welding requires basic high-temperature property data for liquid metals, alloys, and semiconductors. This modeling capability has advanced so much in recent years that its applications are limited by the accuracy with which the property data are known. Important data include: heat capacity, thermal and

chemical diffusivities, optical properties, viscosity, and surface tension. The focus will be on the use of containerless experiments to achieve accurate material property measurements on metallic liquids; determine materials, environments, purities, and operating temperatures for which data are needed by industry; determine the properties that can be measured by Earth-based methods; and establish the measurements requiring the extreme quiescence possible in the low gravity environment of space. Only some of the property measurements of interest will require the quiescence available in space-based experiments and Earth-based capabilities for containerless measurement will be available for the other properties. This will help achieve the important space-based measurements essential to complete the material property compendium and enhance applications of predictive modeling.

Potential Commercial Applications: An integrated high-temperature thermophysical property measurement program will serve two markets: hardware design and construction for NASA, and industrially sponsored measurements of material properties at high temperatures to provide data for predictive modeling of materials processing operations.

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299 MSFC
91-1-15.06-7501 NAS8-39327
Real-Time, Space, Materials-Degradation Monitor Using Ellipsometer
J. A. Woollam Company
650 J Street, Suite 39
Lincoln, NE 68508
Blaine Johs (402-477-7501)

Materials degradation in space is due to the synergistic effects of atomic oxygen and ultraviolet light exposure. Post-flight degradation evaluation is done using spectroscopic ellipsometry, atomic force microscopy, reflectometry, mass loss, electron microscopy, and photothermal deflection spectroscopy. With the exception of ellipsometry, none of these diagnostics are reasonable to fly on space missions for real-time, in-situ sensing. A space-qualified ellipsometer to be used for real-time, in-situ evaluation of materials degradation in space will be developed. It will be lightweight, compact, totally automatic, and highly reliable.

Potential Commercial Applications: This will make an excellent instrument for numerous materials degradation and contamination problems (e.g., corrosion) in terrestrial as well as space applications.

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300 KSC
91-1-15.07-9471 NAS10-11867
Compact, Automated, Frequency-Agile Microspectrofluorimeter for Use in an Unmanned Space Vehicle Environment
Ciencia, Inc.
111 Roberts Street, Suite K
East Hartford, CT 06108
Salvador Fernandez (203-659-9471)

The goal of this project is to produce and validate a design for an automated microspectrofluorimeter that would be capable of maintaining a series of living cell cultures in an unmanned space vehicle environment and would be able to subject any selected culture to any of a set of optical analyses under programmed control. The instrument would be designed around the use of acousto-optic tunable filters (AOTF) that would provide microsecond spectral bandpass selection, millisecond scanning, and nanometer spectral resolution. Data collection would be achieved by an image projected on a linear two-dimensional charged-coupled device (CCD) detector then the data would be recorded and/or transmitted to a base station. Phase II would result in the construction and testing of a complete and functional instrument system.

Potential Commercial Applications: While the instrument will be a viable product in its own right, it will also serve as the nucleus of a family of spectrafluorometric products that will serve a wide variety of needs in industry and research.

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301 MSFC
91-1-15.08-9591 NAS8-39340
Advanced Flight Hardware for Organic Separations
Space Hardware Optimization Technology
P.O. Box 351
Floyd Knobs, IN 47119
Mark S. Deuser (812-923-9591)

Separation and purification techniques for bioprocesses are an aspect of biotechnology demanding greater attention. Traditional separation techniques are impractical and inefficient for many new bioprocesses, so innovative separation methods must be developed. In combination with the unique environment of space, aqueous two-phase polymer partitioning systems provide a novel process for separating organic materials. Phase I will analyze the microgravity partitioning separation process, and refinements will be recommended to increase the productivity and applicability of the process. Concurrently, innovative concepts for a space-qualified apparatus will be developed for studying and performing separations of organic materials by partitioning in immiscible polymer systems under microgravity conditions. A concept for a novel separation apparatus which may be used by academic, government, and corporate laboratories to better understand gravity's role in separation processes will be

developed. The flight hardware concept will offer an innovative approach to low-gravity fluids research in general, phase separation and partitioning in particular, and provide insight into potential ground- and space-based commercial ventures that could develop from the novel separation process.

Potential Commercial Applications: The innovative flight hardware could lead to improved separation methods for the biotechnology industry and even the need for ongoing separation services in microgravity. The research could pilot the development of novel separation equipment that could be commercially marketed to research laboratories.

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Appendix A: Description of the SBIR Program

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) program was instituted in 1982 by Public Law 97-219 and re-authorized through Fiscal Year 1993 by the enactment of Public Law 99-443 in 1986. Implementation of the program follows policy directives issued by the Small Business Administration (SBA). Eligibility is limited to U.S.-owned companies operating in the U.S. having fewer than 500 employees at the time a contract is awarded.

Purposes

The purposes of the Small Business Innovation Research program include stimulating U.S. technological innovation in the private sector, strengthening the role of small businesses in meeting Federal research and development needs, increasing the commercial application of Federally supported research results, and fostering and encouraging participation by minority and disadvantaged persons in technological innovation. Achievement of these purposes is accomplished through actions taken by the agency to meet its own particular R&D needs within the program framework established by laws and the SBA policy directive guidelines.

SBIR Program Phases

As specified by the enabling legislation, SBIR is a three-phase R&D program. For Phase I, the objectives are to establish the feasibility and merit of an innovative scientific or technical concept proposed by a small business. Firms respond to a need or opportunity delineated by an agency in its annual Program Solicitation. Contracts for Phase I are awarded through a competitive selection process based on the evaluation of Phase I proposals submitted in response to a Solicitation.

Phase II of SBIR is the principal research and development effort. Its purpose is the further development of the proposed ideas to meet the particular program needs. Only Phase I contractors may submit proposals to continue their Phase I research into Phase II. The selection of Phase II awards considers the scientific and technical merit and feasibility evidenced by the first phase, the expected value of the research to the agency, and the competence of the firm to conduct Phase II. In addition, for Phase II proposals considered to have essentially equivalent scientific merit and feasibility, special consideration is given to those that include valid non-Federal funding commitments for Phase III activities.

In Phase III, a small business can pursue commercial applications of the results of its SBIR-funded research. Phase III for commercial purposes is strongly encouraged by NASA as a major SBIR objective. Phase III may also take the form of follow-on R&D or production contracts with NASA or other Federal agencies for products and processes intended for use by the United States Government; however, such Phase III activities cannot be supported by the SBIR program funding set-aside.

Phase I and II Funding

NASA funding for SBIR projects is in keeping with guidelines for the SBIR program issued by the Small Business Administration. Phase I contracts are generally limited to six months in duration and $50,000, while contracts for Phase II are normally limited to two years' duration and funding of not more than $500,000. NASA may make justifiable exceptions.

Proposal Evaluation and Award Selection

Evaluations of both Phase I and II proposals follow SBA policy guidelines and include technical merit and innovativeness, NASA R&D needs and priorities, program balance, and company capabilities. There are no quotas for specific technical areas. For Phase II, the Phase I results are a major factor and unlike Phase I, cost is an important consideration. And as noted above, for Phase II proposals of essentially equivalent merit, special consideration is given to those which include valid non-federal capital commitments for Phase III activities, particularly for pursuing commercial applications. Evaluators include NASA technical staff members at the Field Centers responsible for the Subtopics and the NASA Headquarters program officials. NASA, at its discretion, may also use outside evaluators.

Program History

Initiated in 1983, the NASA SBIR program has been supporting innovative R&D projects of interest to the agency and the aerospace community with funds set aside from the agency's research and development budget. As required by law, funding is 1.25 percent of NASA's annual budget for R&D contracting. For Fiscal Year 1991, $75 million was provided to the NASA SBIR program. Including the amount set aside for 1992, the NASA SBIR program funding for all years of the program amounts to more than $427 million. Thus far 1813 Phase I and 770 Phase II awards have been made. Since the NASA budget supports, in large part, the accomplishment of dedicated mission and R&D goals and has limited flexibility in the optional use of these specifically budgeted funds, the SBIR program constitutes a significant portion of the agency's discretionary research effort.

Small businesses have responded vigorously to the opportunities presented by the SBIR program. The number of Phase I proposals grew from 977 in 1983 to 2,533 in 1992. The number of Phase I awards selected has been limited each year not by the number of acceptable proposals but by the funds available and the desire that at least half of the Phase I projects proceed into Phase II. Awards have been made to 875 firms in 43 states, the District of Columbia and Puerto Rico. Approximately 17 percent of the firms submitting proposals have received Phase I awards, and about 43 percent of those firms have received Phase II continuations.

Appendix B: 1991 Topics and Subtopics

01 Aeronautical Propulsion and Power

- 01.01 Internal Fluid Mechanics for Aeronautical Propulsion Systems
- 01.02 Aeropropulsion Systems Components
- 01.03 Aeropropulsion Systems Instrumentation, Sensors, and Controls
- 01.04 Novel Aeropropulsion Concepts

02 Aerodynamics and Acoustics

- 02.01 Computational Fluid Dynamics
- 02.02 Flow Physics Modeling and Control
- 02.03 Hypersonic Vehicle Aerothermodynamics
- 02.04 Configurational Aerodynamics Including Vortices
- 02.05 Unsteady Aerodynamics and Aircraft Dynamics
- 02.06 Rotorcraft Aerodynamics and Dynamics
- 02.07 Wind Tunnel Design and Experimental Techniques
- 02.08 Wind Tunnel Instrumentation
- 02.09 Aircraft Noise Prediction and Reduction
- 02.10 Propulsion Noise Reduction

03 Aircraft Systems, Subsystems, and Operations

- 03.01 Aircraft Ice-Protection Systems
- 03.02 Aircraft Weather Environment
- 03.03 Control Concepts for Fixed-Wing Aircraft
- 03.04 Fully Automatic Guidance for Rotorcraft
- 03.05 Flight Research Sensors and Instrumentation
- 03.06 Aircraft Flight Testing Techniques
- 03.07 Hypersonic Flight Systems Technology
- 03.08 Very-High Altitude Aircraft Technology
- 03.09 Aeronautical Human Factors and Flight Management
- 03.10 Testing and Verification of Flight Critical Systems
- 03.11 Aerospace Vehicle Flight Characteristics Simulation

04 Materials and Structures

- 04.01 High-Temperature Composite Materials for Aeropropulsion
- 04.02 High-Temperature Polymer-Matrix Composites for Aeropropulsion
- 04.03 Computational Structural Methods for Aeropropulsion
- 04.04 Computational Methods for Aeropropulsion Materials Processing
- 04.05 Composite Materials for Aerostructures and Space Applications
- 04.06 Light Alloy Metallics and Metal-Matrix Composites for Airframes
- 04.07 Oxidation-Resistant Carbon-Carbon Composites for Aerostructures
- 04.08 Alloys for Advanced Rocket Propulsion Systems
- 04.09 Thermal Protection Materials and Systems
- 04.10 Spacecraft Structures and Mechanisms
- 04.11 Space Mechanical Components
- 04.12 Lubricants for Aeronautics and Space Applications
- 04.13 Mechanical Joining Methods
- 04.14 Welding Technology
- 04.15 Aluminum and Magnesium Composites for Structural Connectors
- 04.16 Special Fabrication and Hardware Verification Techniques
- 04.17 Nondestructive Evaluation to Characterize Material Properties
- 04.18 Special Purpose Materials for Space Applications
- 04.19 Electrically Conductive and Nonlinear Optical Polymeric Materials
- 04.20 Environmental Effects & Degradation of Surfaces in Space
- 04.21 Adaptive Aerospace Structures and Materials
- 04.22 High-Damping for Lightweight Structures
- 04.23 Lunar Materials Utilization

05 Teleoperators and Robotics

- 05.01 Telerobotic Vision Systems Technology
- 05.02 Non-Visual Sensing for Robotic Applications
- 05.03 Space Robotic Mechanisms
- 05.04 End Effectors
- 05.05 Robotic Control Systems
- 05.06 Servicing and Assembly by Robotics and Teleoperators
- 05.07 Telerobotic Applications of Bionics and Biomimetics

06 Computer Sciences and Applications

- 06.01 Computational Advances for Aerospace Applications
- 06.02 Software Support Systems for Unmanned Missions
- 06.03 Reliable Software Development
- 06.04 Knowledge-Based Systems for Aerospace Applications
- 06.05 Software Systems for Mission Planning and Flight Control
- 06.06 Discrete Event Simulation for Operations Planning
- 06.07 Spaceflight Data Systems
- 06.08 Optical Processing Technology
- 06.09 Computer Tomography Using CAD-CAM and FEM Modeling

07 Information Systems and Data Handling

07.01 Focal-Plane Image Processing
07.02 Software for Massively Parallel Computing Systems
07.03 Spatial Data Management and Geographic Information Systems
07.04 Information Processing Technology and Integrated Data Systems
07.05 Heterogeneous Distributed Data Management
07.06 On-Board Science Data Management and Storage
07.07 Advanced Remote Sensing Database Technology
07.08 Optical-Domain Processing of Laser Signals
07.09 Digital Signal Processing for Real-Time Data Acquistion
07.10 Low-Cost Solid-State Recorder
07.11 Search for Extraterrestrial Intelligence

08 Instrumentation and Sensors

08.01 Earth Atmospheric and Topographic Measurements from Space
08.02 Low-Frequency, Airborne, Remote Sensing Instrumentation
08.03 LIDAR Systems for Earth Atmospheric Remote Sensing
08.04 Sensors for Aerosol and Cloud Studies
08.05 Calibration Systems for Airborne Sensors
08.06 Tunable Solid State Lasers, Detectors & LIDAR for Orbiting Platforms
08.07 Earth-Observing Sensors Geostationary Orbit Platforms
08.08 Tunable Diode Lasers for Airborne Spectrometers for Remote Sensing
08.09 Liquid Crystal Tunable Filter for Remote Sensing
08.10 Vegetation Structure Analysis System
08.11 Detectors and Detector Arrays
08.12 Heterodyne Technology
08.13 Technology for Infrared Astronomical Applications
08.14 Submillimeter Antennas, Radiometers, and Spectrometers
08.15 Instrumentation for Exobiology
08.16 Oceanographic Instrumentation
08.17 Optical Components for Earth-Orbiting Spacecraft
08.18 Optical Components for Planetary Science and Astrophysics
08.19 Instrumentation for Charged Particiles and Gamma Ray Astronomy
08.20 III-V Semiconductor Laser Diode Technology
08.21 Electro-Optical Sensor Systems for Planetary Exploration
08.22 Optoelectronics for Space Science and Engineering
08.23 Receivers for Low Radio Frequencies

09 Spacecraft Systems and Subsystems

09.01 Spacecraft Attitude Determination and Control
09.02 Unmanned Spacecraft Control
09.03 Autonomous Guidance and Control Systems for Spacecraft
09.04 Control of Large Flexible Space Structures
09.05 Cryogenic Fluid Systems Components and Instrumentation
09.06 Cryogenic Refrigeration Materials and Components
09.07 Thermal Control for Unmanned Spacecraft
09.08 Manned Spacecraft Thermal Systems
09.09 Spacecraft Contamination
09.10 Spacecraft Meteoroid and Debris Protection Systems
09.11 Crew Workstation Displays and Controls
09.12 Artificial Intelligence for Space Station Applications
09.13 Maneuverable Recovery System for Balloon Payloads

10 Space Power

10.01 Dynamic Energy Conversion
10.02 Photovoltaic Energy Conversion
10.03 Thermal-to-Electric Energy Conversion Technology
10.04 Photovoltaic Laser Energy Conversion
10.05 High-Performance Photovoltaic Solar Arrays
10.06 Electrochemical Storage Systems
10.07 High-Specific-Energy Batteries for Unmanned Applications
10.08 Portable Rechargeable Energy Storage for Manned Applications
10.09 Radioisotope-Fueled Batteries
10.10 Power Management and Distribution
10.11 Power Processing

11 Space Propulsion

11.01 Computational Fluid Dynamics for Rocket Propulsion
11.02 Thermal Technology for Chemical Propulsion Systems
11.03 Propulsion System Combustion Processes
11.04 Solid Rocket Motor Technology
11.05 Expert Systems for Solid Rocket Motor Design and Analysis
11.06 Liquid Rocket Propulsion Design and Analysis
11.07 Diagnostic Techniques for Liquid Rocket Engines
11.08 Durability Analysis for Launch Vehicle Engines
11.09 Magnetic Suspension Bearing Technology
11.10 Unconventional Chemical Rocket Engines and Components
11.11 High-Temperature Superconducting Solenoid Magnet
11.12 Advanced Space Propulsion Concepts

12 Human Habitability and Biology in Space

- 12.01 Medical Sciences for Manned Space Programs
- 12.02 Biomedical and Environmental Health Sciences for Manned Space Programs
- 12.03 Micro-Gravity Effects on Human Physiology
- 12.04 Regenerative Life Support: Air, Water, and Waste Management
- 12.05 Regenerative Production of Food
- 12.06 Bioregenerative Life Support Utilizing Microorganisms
- 12.07 Human Factors for Space Crews
- 12.08 Human Performance in Space
- 12.09 Man-Systems Integration in Space Systems
- 12.10 On-Board Systems and Support for Space Crews
- 12.11 Extra-Vehicular Activity (EVA)
- 12.12 Optical Systems and High Resolution Electronic Still Photography
- 12.13 Life Sciences Spaceflight Technology

13 Quality Assurance, Safety, and Check-Out for Ground and Space Operations

- 13.01 Launch and Ground Weather Forecasting
- 13.02 Portable Meteorological Station
- 13.03 Contamination Monitoring for Launch Site Operations
- 13.04 Fluid Systems Components
- 13.05 Fluid and Gas Leak Detection Systems
- 13.06 Cryogenic System Components Testing
- 13.07 Toxic Propellant Detection
- 13.08 Pre-Launch Testing of Advanced Microcircuits
- 13.09 Nondestructive Evaluation for Launch Readiness Verification
- 13.10 Engine Hardware Inspection
- 13.11 Structural Composite Materials for the STS Launch Environment
- 13.12 Active-Passive Cathodic Protection Systems
- 13.13 Facilities Pavement Scanner System
- 13.14 Solvents for Flushing Components and Sampling Cleanliness Levels

14 Satellite and Space Systems Communications

- 14.01 Communications for Manned Space Systems
- 14.02 Data Relay Satellite Systems
- 14.03 Optical Communications for Deep Space
- 14.04 Spacecraft Telecommunication and Deep Space Network Systems
- 14.05 RF Components for Satellite Communications Systems
- 14.06 Digital Systems for Satellite Communications
- 14.07 Low Cost Ka-Band Ground Terminals
- 14.08 Ka-Band User Antennas for Personal Communications
- 14.09 High Temperature Superconductor Microwave and Millimeter Wave Components

15 Materials Processing, Microgravity, and Commercial Applications in Space

- 15.01 Materials Processing in Space
- 15.02 Microgravity Science, Engineering, and Applications
- 15.03 Chemical Vapor Deposition Analysis and Modeling Tools
- 15.04 Non-Contact Temperature Measurement
- 15.05 Thermophysical Properties Measurements in Micro-Gravity
- 15.06 Structural Degradation Sensors for Space Environment Effects
- 15.07 Photometer-Fluorometer for Space-Based Study of Live Cells
- 15.08 Separation of Organic Materials

Appendix C: Index of 1991 Phase I Projects By State

Appendix D: Index of Participating Companies

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I

Intelligent Automation, Inc.
Rockville, MD 20850
077: Fast Three-Dimensional Imaging
088: Magnetostrictive Bi-Directional Linear Actuator

Intelligent Decisions, Inc.
Sunnyvale, CA 94089
182: Stellar Compass for Autonomous Spacecraft Guidance and Control

Interferometrics, Inc.
Vienna, VA 22182-2799
199: Spacecraft, Hypervelocity-Impact-Protection, Ceramic-Based Shielding

Intersonics, Inc.
Northbrook, IL 60062
298: High-Temperature, Containerless, Thermophysical Property Measurements in Microgravity

Iowa Thin Film Technologies, Inc.
Ames, IA 50010
206: Flexible, Lightweight, Copper Indium Diselenide/Cadmium Sulfide, Monolithic, Solar Cells Interconnected in a Roll-to-Roll Process

Irvine Sensors Corporation
Costa Mesa, CA 92626
144: Real-Time, Self-Contained, Image-Motion Compensation for Spaceborne Imaging Instruments

Ithaco, Inc.
Ithaca, NY 14851-6437
178: Codeless, Global-Position-System, Attitude-Determination System

J

J. A. Woollam Company
Lincoln, NE 68508
299: Real-Time, Space, Materials-Degradation Monitor Using Ellipsometer

JAI Associates, Inc.
Mountain View, CA 94043
019: Simulation of Helicopter Rotor-Body Interaction Flow Fields by Navier-Stokes Method

Jortner Research & Engineering, Inc.
Costa Mesa, CA 92626
224: Micromechanical Model for Structural Response and Failure of Rapidly Heated, Carbon-Phenolic Laminates

K

Kingsbury, Inc.
Philadelphia, PA 19154
231: Experimental Method for the Extraction of Magnetic-Bearing-System Rotordynamic Coefficients

KMS
Ann Arbor, MI 48106-1567
111: Realistic Virtual Environment Workstation

Kopin Corporation
Taunton, MA 02780
208: Aluminum-Gallium-Arsenide, Photovoltaic, Space-Laser Energy Converters
209: Hardened, Thin-Film Aluminum-Galium-Arsenide Solar Cells with Specific Power Over 700 Watts/Kilogram

Korsch Optics, Inc.
Huntsville, AL 35803
169: Wide-Field Telescope with Zoom Capability for Planetary Observations

Kulite Semiconductor Products, Inc.
Leonia, NJ 07605
006: Hexagonal-Silicon-Carbide Crystal Pressure Sensors for High-Temperature Applications

L

Largo Scientific, Inc.
Largo, FL 34641
274: Pultruded Structural Composites Having High Flammability Resistance and Electrical Conductivity

Laser Data Technology, Inc.
St. Louis, MO 63132
281: Automatic Co-Alignment of Multiple Diode Laser Beams

Laser Photonics, Inc., Analytics Division
Bedford, MA 01730
145: Tunable Diode Lasers for Airborne Spectrometers for Atmospheric Sensing
162: Thermoelectrically Cooled, Tunable, Diode-Laser Source Assembly

Laser Power Corporation
San Diego, CA 92130
168: Dynamic Evaluation of Aspheric Surfaces in Real Time
282: Frequency-Stabilized, Microlaser Local Oscillator

Life Systems, Inc.
Cleveland, OH 44122
248: Electrochemical Ozone Generator for In Situ Sterilization of Potable Water and Wastewater

Luxel Corporation
Friday Harbor, WA 98250
166: Applications of Thin Polyimide Films to X-Ray Optics

Lynntech, Inc.
Bryan, TX 77803
070: Novel Processing Technology for Stable Electronically Conducting Polymers
246: Integrated System for Resource Recovery from Multiple Waste Streams

M

Mainstream Engineering Corporation
Rockledge, FL 32955-5327
267: Production of High-Purity Liquid Amonia
278: An Innovative Approach for Solvent Selection

Materials & Electrochemical Research
Tucson, AZ 85706
050: An Advanced Carbon-Carbon Composite with Improved Interlaminar and Flexure Properties and Oxidation Resistance
052: A Unique Silicon-Carbide Reusable Thermal Protection Material
244: Electrochemical Reduction of Carbon-Dioxide Using a Novel Electrode System

Mayflower Communications Company, Inc.
Reading, MA 01867
181: Autonomous, Reconfigurable, Global Positioning System and Dual Cone Scanner Navigation and Pointing Control System

MDA Engineering, Inc.
Arlington, TX 76010
002: A Deformation Model for Producing Adaptive Grids

Membrane Technology & Research, Inc.
Menlo Park, CA 94025
245: Removal of Nitrogen from Carbon-Dioxide-Rich Streams

Merritt Systems, Inc.
Merritt Island, FL 32954-2103
085: Sensor Technology for Robotic Obstacle Avoidance

Micro-Bac International, Inc.
Austin, TX 78758
252: Light-Driven, Waste-Remediation System Utilizing Phototrophic Bacteria

Microgravity Systems, Inc.
Brownsboro, AL 35741
291: High-Field, Low-Mass, Permanent Magnet and Shielding for Applications in Space

Millitech Corporation
South Deerfield, MA 01373
161: A High-Power, Wide-Band, Synthesized Source for 90 Gigahertz
288: A Flat, Dual-Band Array at 20 and 30 Gigahertz for Small-User Communication Terminals

ML Energia, Inc.
Princeton, NJ 08542
008: Advanced Photochemical Techniques for Relight and Combustion Enhancement of Supersonic Transport Aircraft Systems

Moco, Inc.
Scituate, MA 02055
253: Nonstandard Functional Limb Trajectories

Moltech Corporation
Stony Brook, NY 11794-2275
129: High-Density, Optical Data Storage in a Novel, Flexible Medium with Built-In Focusing Microspheres

MXR, Inc.
Dexter, MI 48130
082: A Compact, Solid-State Range Sensor with Millimeter Depth Resolution

N

Nastec, Inc.
Cleveland, OH 44114
055: Traction Drives for Reaction-Free and Momentum-Balanced Systems

Neocera, Inc.
College Park, MD 20742-3261
155: Redeposition of High-T_c Films on Diamond for Infrared Detectors

Netrologic, Inc.
San Diego, CA 92122
094: Robotic Analog of Biological Tissue for Mechanical Transduction

Nielsen Engineering & Research, Inc.
Mountain View, CA 94043-2287
010: A Mathematically Based Reynolds-Stress Model of Turbulence
018: A Prediction Method for High-Angle-of-Attack Aerodynamics
024: Methods for Computational Aeroacoustics
028: Ice-Accretion Prediction on Massively Parallel Computers

Nienhaus & Associates
Greenfield, IN 46140
113: Operations Planning with Neural Networks

Northeast Semiconductor, Inc.
Ithaca, NY 14850
176: High-Power, Single-Mode, Diode Lasers Operating at 1.047 Microns to 1.064 Microns

Northwest Technology Industries, Inc.
Sequim, WA 98382
226: Creating Turbine Discs from Explosively Welded Molybdenum-Niobium Laminates

O

OCA Applied Optics, Inc.
Garden Grove, CA 92642
136: Ultra-Lightweight, Large-Aperture, Space-Based Telescope

Optivision, Inc.
Palo Alto, CA 94304
125: A Highly Concurrent Multiwavelength Fiber-Optic Network
268: Reliable and Rugged Fiber-Optic Sensors for Detecting Hydrogen Leaks and Hydrogen-Chloride Doses

Optra, Inc.
Beverly, MA 01915
032: A Three-Component, Optical, Doppler Air Velocity Sensor

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S

S-Tron
Mountain View, CA 94043
254: Virtual Environment Interface

Sarcos Research Corporation
Salt Lake City, UT 84111
256: Space-Suit Glove Tester

Satcon Technology Corporation
Cambridge, MA 02139-4507
072: Adaptive Materials Using Magnetostrictive Actuation
086: Advanced Induction Servomotor
164: High-Precision Spectrometer Movement
184: A Superconducting, Ultra-Precision Multi-Sensor

Schmidt Instruments, Inc.
Houston, TX 77005
071: Amorphous-Diamond, Protective Coatings for Exposed Surfaces in Low-Earth Orbit
270: Miniature, Ruggedized Mass Spectrometer

Schwartz Electro-Optics, Inc.
Orlando, FL 32804
137: Low-Voltage Spaceborne Q-Switch

Science & Engineering Services, Inc.
Burtonsville, MD 20866
080: Multi-Beam, Diode-Laser Radar for Non-Visual Sensing

Science Research Laboratory, Inc.
Somerville, MA 02143
227: Multiple-Beam Spectroscopy for Liquid-Rocket-Engine Diagnostics

Scientific Applications & Research Associates
Huntington Beach, CA 92649
263: MUSIC Thunderstorm Location from Spatio-Temporal Electric Field Mill Data

Scientific Computing Associates, Inc.
New Haven, CT 06510-7010
100: Piranha Parallelism: Distributed Self-Management of Computing Resources in a Network Environment

Scientific Materials Corporation
Bozeman, MT 59715
142: Lutetium-Aluminum-Garnet and Yttrium-Scandium-Garnet for 2.1-Micron Lasers

Scientific Research Associates, Inc.
Glastonbury, CT 06033
005: Compressor Stall Avoidance and Alleviation
218: An Interactive Tool for Discrete Phase Analysis in Two-Phase Flows
284: Silicon-Germanium-Heterostructure, Bipolar Transistors

SEAKR Engineering, Inc.
Torrance, CA 90503
134: A Non-Volatile, Solid-State Recorder for Spacecraft

Search Technology, Inc.
Norcross, GA 30092
039: Improving Access and Use of Graphical Information in Commercial Air Transport

Seca, Inc.
Huntsville, AL 35805
220: Conjugate Heat-Transfer Analysis for Solid Rocket Motors

Sensor Systems Group, Inc.
Waltham, MA 02154
295: Spatial, Infrared, Spectral Sensor for Micro-Gravity Combustion Experiments

Sensors Unlimited, Inc.
Princeton, NJ 08540
157: A Monolithic, InGaAs-FET Detector Array for Near-Infrared Imaging

Shason Microwave
Houston, TX 77058
279: Digital Communication System Integration

Sigmatech, Inc.
Huntsville, AL 35805
132: Hybrid, Multiple-Object-Recognition System for a Laser Radar Image

Software Productivity Solutions, Inc.
Indialantic, FL 32903
105: Intelligent Pen-Based Engineering Notebook

Sohar, Inc.
Beverly Hills, CA 90211-3204
091: A Fault-Tolerant, Intelligent, Robotic Control System

Space Computer Corporation
Santa Monica, CA 90404-4119
287: Algorithm for Video Data Compression Based on Improved Moving Picture Experts Group

Space Hardware Optimization Technology
Floyd Knobs, IN 47119
301: Advanced Flight Hardware for Organic Separations

Space Power, Inc.
San Jose, CA 95134
061: Space Welding Power Control Unit

Spaceborne, Inc.
La Canada, CA 91011
159: A One-Gigahertz, 256-Channel, Low-Power, Single-Chip, CMOS Digital Correlator Spectrometer

Spire Corporation
Bedford, MA 01730-2396
156: Long-Wavelength, Gated, Mercury-Cadmium-Telluride, N+N-P, Photodiodes for Heterodyne Applications
172: High-Growth-Rate, Atomic-Layer-Epitaxy Reactor for III-V Materials
200: Silicon-Based, Full-Color, Flat-Panel Display
215: High-Density, Long-Life, Radionuclide, Voltaic Energy Source
283: Monolithic, Integrated, Heterodyne-Receiver Chip

Statistical Sciences, Inc.
Seattle, WA 98109
109: Computing Environments for Graphical Belief Models
123: Wavelet-Based Compression and Visualization of Time Series of Images

T

U

V

VRA, Inc.
Blacksburg, VA 24063
013: Navier-Stokes Technique for Aerobraking-Orbital-Transfer Vehicles

W

Wickman Spacecraft & Propulsion Company
Citrus Heights, CA 95621-7179
233: Hydrocarbon-Liquid-Oxygen Monopropellants

X

Xechem, Inc.
New Brunswick, NJ 08901-3279
239: Microbial Evaluation in Space Station Using New Hexoid Plates

Appendix E: Index of Principal Investigators

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Appendix F : Index of Projects Managed By Each NASA Center

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017	91-1-02.04-9090
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035	91-1-03.05-8775A
036	91-1-03.06-0533
038	91-1-03.08-7212A
040	91-1-03.10-0655
041	91-1-03.10-3302
053	91-1-04.09-2525
054	91-1-04.09-6881
098	91-1-06.01-2935
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108	91-1-06.04-6882
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117	91-1-06.08-8933
135	91-1-07.11-1414
150	91-1-08.10-5649A
158	91-1-08.13-6700
162	91-1-08.15-2650
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246	91-1-12.04-3149
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Goddard Space Flight Center

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095	91-1-05.07-2075
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104	91-1-06.02-6491
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120	91-1-07.02-1400
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156	91-1-08.12-6000
163	91-1-08.16-9621
164	91-1-08.17-0540A
165	91-1-08.17-1910A
166	91-1-08.17-4137
167	91-1-08.17-7513
170	91-1-08.19-1167A
171	91-1-08.19-9500
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176	91-1-08.22-8827
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179	91-1-09.02-5500A
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Jet Propulsion Laboratory

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130	91-1-07.06-9327
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236	91-1-11.12-9915
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Kennedy Space Center

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Lewis Research Center

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043	91-1-04.01-6627
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055	91-1-04.11-1555A
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Marshall Space Flight Center

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056	91-1-04.12-2437
057	91-1-04.12-3200
059	91-1-04.13-1348
060	91-1-04.14-6750
061	91-1-04.14-9500
062	91-1-04.15-3200
073	91-1-04.22-5633
074	91-1-04.22-7351
077	91-1-05.01-2407
078	91-1-05.01-2577
079	91-1-05.02-1377
081	91-1-05.02-1992A
084	91-1-05.02-7199
118	91-1-06.09-7780
131	91-1-07.07-3474
132	91-1-07.08-1188
133	91-1-07.08-5540
143	91-1-08.07-6250
144	91-1-08.07-8211
181	91-1-09.03-2666
193	91-1-09.08-1856
194	91-1-09.08-2991
198	91-1-09.10-6468
215	91-1-10.09-6000
216	91-1-10.10-3633
218	91-1-11.01-0333A
219	91-1-11.01-8051
220	91-1-11.02-2008
221	91-1-11.02-4747
222	91-1-11.02-8581
223	91-1-11.03-6688
224	91-1-11.04-4308
229	91-1-11.08-0618
230	91-1-11.09-0250
231	91-1-11.09-4000
235	91-1-11.12-7652
249	91-1-12.04-7918
252	91-1-12.06-1145
273	91-1-13.10-0175
291	91-1-15.01-2043
292	91-1-15.01-3184
293	91-1-15.01-6551
299	91-1-15.06-7501
301	91-1-15.08-9591

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122	91-1-07.03-1813
123	91-1-07.03-8802
124	91-1-07.03-9467
138	91-1-08.02-1119
141	91-1-08.05-7445
225	91-1-11.04-5649
275	91-1-13.12-2101
276	91-1-13.13-3113
277	91-1-13.13-3970
278	91-1-13.14-3550

Appendix G: Index of Projects By Contract Number

NAS1: Langley Research Center

NAS1-19513	037	03.07-2900
NAS1-19514	023	02.09-4986
NAS1-19515	096	06.01-1671
NAS1-19516	102	06.01-8051
NAS1-19517	020	02.07-6621
NAS1-19518	012	02.02-7093
NAS1-19519	033	03.05-7093
NAS1-19520	034	03.05-7637
NAS1-19521	093	05.06-9200
NAS1-19522	099	06.01-3729
NAS1-19523	297	15.03-3800
NAS1-19524	014	02.03-3844
NAS1-19525	048	04.05-9101
NAS1-19526	088	05.03-2407
NAS1-19527	208	10.04-6696
NAS1-19528	050	04.07-1980
NAS1-19529	018	02.05-9457A
NAS1-19530	024	02.09-9457
NAS1-19531	125	07.04-0200
NAS1-19532	183	09.03-6720
NAS1-19533	185	09.04-1522A
NAS1-19534	022	02.08-0003
NAS1-19535	065	04.17-0003
NAS1-19536	140	08.04-0003
NAS1-19537	021	02.07-9200
NAS1-19538	067	04.17-2701
NAS1-19539	066	04.17-1167
NAS1-19540	097	06.01-2006C
NAS1-19541	049	04.06-5444
NAS1-19542	072	04.21-0540
NAS1-19543	184	09.04-0540
NAS1-19544	142	08.06-3772A
NAS1-19545	039	03.09-1457
NAS1-19546	105	06.03-3370
NAS1-19547	030	03.03-2281A
NAS1-19548	119	07.01-1696
NAS1-19549	029	03.02-4545
NAS1-19550	047	04.05-0236
NAS1-19551	013	02.03-2036

NAS2: Ames Research Center

NAS2-13439	032	03.05-2100
NAS2-13440	035	03.05-8775A
NAS2-13442	041	03.10-3302
NAS2-13443	038	03.08-7212A
NAS2-13447	040	03.10-0655
NAS2-13458	036	03.06-0533
NAS2-13505	108	06.04-6882
NAS2-13506	257	12.11-1622
NAS2-13507	150	08.10-5649A
NAS2-13510	054	04.09-6881
NAS2-13511	053	04.09-2525
NAS2-13513	011	02.01-9939
NAS2-13514	009	02.01-1515
NAS2-13515	010	02.01-9457A
NAS2-13516	158	08.13-6700
NAS2-13517	250	12.05-3088
NAS2-13524	031	03.04-1567
NAS2-13526	246	12.04-3149
NAS2-13527	135	07.11-1414
NAS2-13528	098	06.01-2935
NAS2-13529	115	06.08-4100
NAS2-13530	117	06.08-8933
NAS2-13532	242	12.03-3474
NAS2-13534	019	02.06-7722
NAS2-13536	162	08.15-2650
NAS2-13540	101	06.01-7450
NAS2-13553	017	02.04-9090
NAS2-13554	015	02.03-3921
NAS2-13555	254	12.08-4949
NAS2-13556	100	06.01-7442
NAS2-13560	016	02.03-6100

NAS3: Lewis Research Center

NAS3-25935	287	14.06-7733
NAS3-26321	028	03.01-9457A
NAS3-26322	027	03.01-8581
NAS3-26323	233	11.10-5307
NAS3-26324	205	10.01-6551B
NAS3-26325	204	10.01-6551A
NAS3-26326	026	02.10-2585
NAS3-26327	226	11.06-4167
NAS3-26328	001	01.01-4807
NAS3-26329	210	10.06-7270
NAS3-26330	228	11.07-9806
NAS3-26331	008	01.04-7970
NAS3-26332	227	11.07-1122
NAS3-26333	004	01.02-3000
NAS3-26334	005	01.03-0333
NAS3-26389	288	14.07-8551B
NAS3-26390	285	14.05-9392
NAS3-26391	286	14.06-4406
NAS3-26392	284	14.05-0333
NAS3-26505	294	15.01-7200
NAS3-26506	070	04.19-3149
NAS3-26507	045	04.03-7780
NAS3-26508	058	04.12-7792
NAS3-26509	069	04.19-0578C
NAS3-26515	044	04.02-9331
NAS3-26542	296	15.02-3800
NAS3-26543	186	09.05-6010
NAS3-26544	187	09.05-8111
NAS3-26545	295	15.02-0204
NAS3-26568	046	04.04-8080
NAS3-26570	055	04.11-1555A
NAS3-26572	043	04.01-6627
NAS3-26574	298	15.05-1772
NAS3-26576	042	04.01-0018
NAS3-26594	217	10.10-5709
NAS3-26595	206	10.02-9944
NAS3-26598	025	02.10-1421
NAS3-26599	006	01.03-0900

NAS3-26600	007	01.03-9500
NAS3-26601	002	01.01-6660
NAS3-26602	003	01.01-9939

NAS5: Goddard Space Flight Center

NAS5-31880	128	07.06-3666
NAS5-31881	087	05.03-0661
NAS5-31882	281	14.02-2250
NAS5-31883	136	08.01-1667
NAS5-31884	179	09.02-5500A
NAS5-31885	068	04.18-4334C
NAS5-31886	203	09.13-0604
NAS5-31911	104	06.02-6491
NAS5-31912	155	08.11-9937
NAS5-31913	154	08.11-2033
NAS5-31914	165	08.17-1910A
NAS5-31915	095	05.07-2075
NAS5-31916	090	05.03-5991
NAS5-31917	094	05.07-0970
NAS5-31918	151	08.10-8442
NAS5-31919	120	07.02-1400
NAS5-31920	103	06.02-3633
NAS5-31921	137	08.01-1802
NAS5-31922	164	08.17-0540A
NAS5-31923	175	08.22-2288
NAS5-31924	152	08.11-1112
NAS5-31925	166	08.17-4137
NAS5-31926	191	09.07-3221
NAS5-31927	192	09.07-8200
NAS5-31928	177	08.23-0800
NAS5-31929	170	08.19-1167A
NAS5-31930	156	08.12-6000
NAS5-31931	178	09.01-7640B
NAS5-31932	163	08.16-9621
NAS5-31933	167	08.17-7513
NAS5-31934	121	07.02-8100
NAS5-31935	134	07.10-9302
NAS5-31936	139	08.03-1416
NAS5-31937	126	07.04-2276A
NAS5-31938	114	06.07-3474
NAS5-31939	064	04.16-3230
NAS5-31940	189	09.07-2221
NAS5-31941	176	08.22-8827
NAS5-31942	149	08.10-3232
NAS5-31943	127	07.05-5445
NAS5-31944	153	08.11-1190
NAS5-31945	171	08.19-9500
NAS5-31946	197	09.09-1791
NAS5-31947	190	09.07-3021

NAS7: Jet Propulsion Laboratory

NAS7-1158	089	05.03-3064
NAS7-1159	145	08.08-2650
NAS7-1160	161	08.14-8551G
NAS7-1161	283	14.03-6000
NAS7-1162	211	10.07-9450A
NAS7-1163	188	09.06-6708
NAS7-1164	182	09.03-3730
NAS7-1165	174	08.21-0094
NAS7-1166	130	07.06-9327
NAS7-1167	159	08.14-0126
NAS7-1168	113	06.06-5805
NAS7-1169	172	08.20-6000
NAS7-1170	148	08.09-2627
NAS7-1171	147	08.08-9500
NAS7-1172	091	05.05-4717
NAS7-1173	168	08.18-0700
NAS7-1174	282	14.03-0700
NAS7-1175	207	10.03-3800
NAS7-1175	234	11.11-0046
NAS7-1177	160	08.14-8181
NAS7-1178	290	14.08-6076
NAS7-1179	180	09.03-1522
NAS7-1180	129	07.06-7565
NAS7-1181	157	08.13-4661
NAS7-1182	289	14.08-4001
NAS7-1183	236	11.12-9915
NAS7-1184	146	08.08-3666
NAS7-1185	173	08.20-6100
NAS7-1186	080	05.02-1896
NAS7-1187	209	10.05-6696
NAS7-1188	169	08.18-1166

NAS8: Marshall Space Flight Center

NAS8-39301	118	06.09-7780
NAS8-39302	060	04.14-6750
NAS8-39303	223	11.03-6688
NAS8-39304	219	11.01-8051
NAS8-39305	198	09.10-6468
NAS8-39306	051	04.08-7900
NAS8-39307	230	11.09-0250
NAS8-39308	292	15.01-3184
NAS8-39309	273	13.10-0175
NAS8-39310	131	07.07-3474
NAS8-39311	229	11.08-0618
NAS8-39312	074	04.22-7351
NAS8-39313	194	09.08-2991
NAS8-39314	073	04.22-5633
NAS8-39315	084	05.02-7199
NAS8-39316	078	05.01-2577
NAS8-39317	056	04.12-2437
NAS8-39318	235	11.12-7652
NAS8-39319	062	04.15-3200
NAS8-39320	057	04.12-3200
NAS8-39321	193	09.08-1856
NAS8-39322	221	11.02-4747
NAS8-39323	059	04.13-1348
NAS8-39324	079	05.02-1377
NAS8-39325	077	05.01-2407
NAS8-39326	144	08.07-8211
NAS8-39327	299	15.06-7501
NAS8-39328	224	11.04-4308
NAS8-39329	231	11.09-4000
NAS8-39330	181	09.03-2666
NAS8-39331	252	12.06-1145
NAS8-39332	291	15.01-2043
NAS8-39333	081	05.02-1992A
NAS8-39334	133	07.08-5540
NAS8-39335	222	11.02-8581
NAS8-39336	143	08.07-6250
NAS8-39337	218	11.01-0333A
NAS8-39338	220	11.02-2008

NAS8-39339	132	07.08-1188
NAS8-39340	301	15.08-9591
NAS8-39341	061	04.14-9500
NAS8-39342	215	10.09-6000
NAS8-39343	216	10.10-3633
NAS8-39344	249	12.04-7918
NAS8-39345	293	15.01-6551

NAS9: Johnson Space Center

NAS9-18666	258	12.11-3200
NAS9-18667	247	12.04-3200
NAS9-18668	279	14.01-1950
NAS9-18669	109	06.04-8802
NAS9-18670	112	06.05-8522
NAS9-18671	241	12.02-7818
NAS9-18672	256	12.11-0560A
NAS9-18673	086	05.03-0540
NAS9-18674	195	09.08-6551B
NAS9-18675	271	13.07-5668
NAS9-18676	214	10.08-9450A
NAS9-18677	201	09.12-8414A
NAS9-18678	200	09.11-6000
NAS9-18679	280	14.01-8933
NAS9-18680	199	09.10-8500B
NAS9-18681	082	05.02-2803
NAS9-18682	238	12.01-9027
NAS9-18683	240	12.02-7770
NAS9-18684	255	12.10-8100A
NAS9-18685	076	04.23-8899
NAS9-18686	063	04.16-0328
NAS9-18687	202	09.12-8414B
NAS9-18688	243	12.04-1583A
NAS9-18690	244	12.04-1980
NAS9-18691	052	04.09-1980
NAS9-18692	253	12.07-2040
NAS9-18693	071	04.20-9040
NAS9-18694	092	05.06-7730
NAS9-18695	245	12.04-2228
NAS9-18696	111	06.05-8500A
NAS9-18697	116	06.08-6116
NAS9-18698	232	11.10-0236
NAS9-18699	248	12.04-3291B
NAS9-18701	239	12.02-3300
NAS9-18702	196	09.08-8200A
NAS9-18703	237	12.01-4220
NAS9-18704	083	05.02-5042
NAS9-18705	212	10.08-1140
NAS9-18706	107	06.04-1400
NAS9-18707	260	12.12-7947A
NAS9-18708	213	10.08-9450
NAS9-18709	106	06.03-3491
NAS9-18710	259	12.11-5668
NAS9-18711	110	06.05-8181
NAS9-18712	075	04.23-3697A

NAS10: Kennedy Space Center

NAS10-11853	262	13.01-2621
NAS10-11854	261	13.01-0655
NAS10-11855	268	13.05-0200
NAS10-11856	266	13.04-2888
NAS10-11857	263	13.01-5509
NAS10-11858	264	13.03-0202
NAS10-11859	269	13.05-8899
NAS10-11860	085	05.02-7828
NAS10-11861	251	12.05-7070A
NAS10-11862	270	13.05-9040
NAS10-11863	267	13.04-3550
NAS10-11864	272	13.09-0056
NAS10-11865	265	13.03-6239
NAS10-11866	274	13.11-1946
NAS10-11867	300	15.07-9471

NAS13: Stennis Space Center

NAS13-478	124	07.03-9467
NAS13-479	141	08.05-7445
NAS13-480	276	13.13-3113
NAS13-481	122	07.03-1813
NAS13-482	225	11.04-5649
NAS13-483	123	07.03-8802
NAS13-484	278	13.14-3550
NAS13-485	138	08.02-1119
NAS13-486	275	13.12-2101
NAS13-487	277	13.13-3970