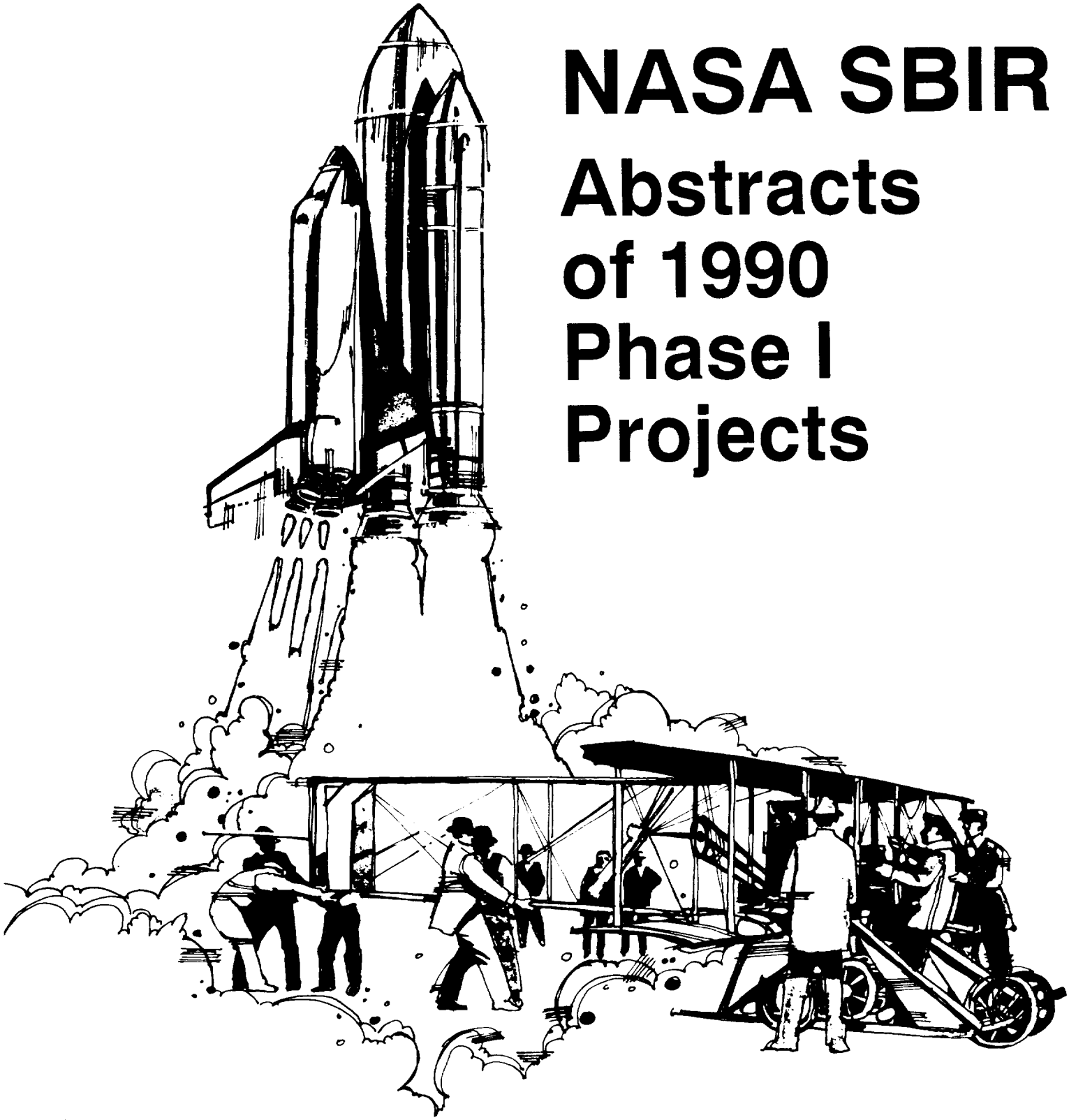
PC-90

NASA SBIR
Abstracts of 1990 Phase I Projects



NASA

National Aeronautics and Space Administration

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.

August 1991

Introduction

Objective

The purpose of this document, *Abstracts of 1990 Phase I Projects*, is to describe the research objectives of the 280 projects placed under contract in the National Aeronautics and Space Administration (NASA) 1990 SBIR Phase I program.

Contents

The basic document consists of edited, non-proprietary abstracts of the winning proposals submitted by small businesses in response to NASA's 1990 SBIR Phase I Program Solicitation. 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 280, 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 1990 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 1990 Phase I Projects

The closing date for the 1990 SBIR Phase I Program Solicitation was July 16, 1990, at which time 2148 proposals has been received. Following evaluation and selection of proposals for contract negotiation, 6-month fixed-price contracts were placed for 280 projects with 225 small businesses in 30 states to determine the feasibility of the proposed innovations. All projects were conducted during calendar year 1991. It is planned that approximately half of the successfully completed Phase I projects will be chosen in late 1991 and early 1992 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 1990 included the 164 subtopics listed in Appendix B.

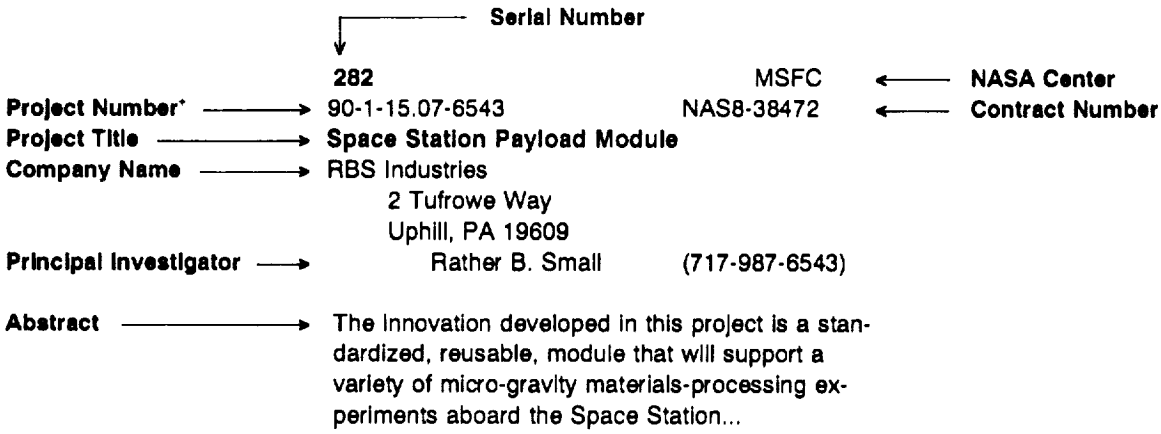
Program Management

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 (90), 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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NASA

Small Business Innovation Research

Abstracts of 1990 Phase I Projects

01: Aeronautical Propulsion and Power

001 LeRC
90-1-01.01-1515 NAS3-26234
Advanced Turbomachinery CFD Design and Analysis Program
Cambridge Hydrodynamics, Inc.
P.O. Box 1403
Princeton, NJ 08542
Iyla Staroselsky (609-683-1515)

Computational fluid dynamics (CFD) tools have now developed to the point where they can be reliably used for the design, evaluation, and analysis of such high-performance gas turbines as those used in modern aeronautical propulsion systems. For these applications, it is necessary to use a three-dimensional viscous CFD code that combines efficiency, accuracy, and user-friendliness. For axial turbomachinery, the prediction and analysis of secondary flows, blade heat transfer, transition, and unsteadiness at on- and off-design conditions require the use of new, advanced models like that provided by the renormalization group (RNG) methods developed by the company. This project will develop enhanced supercomputer and massively parallel processor versions of the NEKTON CFD code with RNG models for transition and turbulence to address turbomachinery applications. This involves integrating variable geometry, complex blade rows, transition and turbulence modelling, and shock-boundary layer interactions while addressing central compressor, diffuser, and turbine design issues.

Potential Commercial Applications: This program should find application in the advanced design of gas turbine devices and stream turbomachinery.

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002 LeRC
90-1-01.01-6576 NAS3-26144
A Probability Density Function Method for Turbulent, Reacting Flows
CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
Andy D. Leonard (205-536-6576)

Modeling methods developed for non-reacting turbulent flows are not able to capture important interactions of turbulence and combustion. An alternative approach solves an equation for the joint probability density function (PDF) of the local velocity and composition, instead of solving a set of equations for their first- and second-order moments. While PDF methods have been proposed in the past, they have only been used in certain simplified situations. In this project, the company will develop an efficient PDF solution procedure for general reacting flows. In Phase I, a stand-alone module will be developed using a Lagrangian Monte Carlo solution method. The module will be validated by comparison with benchmark data. These comparisons will be used to assess the feasibility of the PDF method and to determine the requirements for coupling the module with a finite-volume CFD code. In Phase II, the coupling would be performed and the methodology extended to three-dimensional flows. The PDF module and finite volume code would be fully documented and delivered to NASA at the end of Phase II.

Potential Commercial Applications: The developed PDF module and coupled CFD code will advance the state-of-the-art of numerical simulations of turbulent reactive flows for use by organizations associated with aeronautical and space propulsion systems.

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003 LeRC
90-1-01.01-9500 NAS3-26242
A New, Unsteady Mixing Model to Predict NOx Production During Rapid Mixing in a Dual Stage Combustor
Quest Integrated, Inc.
21414 68th Avenue South
Kent, WA 98032
Suresh Menon (206-872-9500)

An advanced gas turbine engine to power supersonic transport aircraft is currently under study. In addition to high combustion-efficiency requirements, environmental concerns have placed stringent restrictions on the pollutant emissions from these engines. A combustor design with the potential for minimizing pollutants such as NOx emissions is undergoing experimental evaluation. A major technical issue in the design of this combustor is how to rapidly mix the hot, fuel-rich primary-zone product with the secondary diluent air to obtain a fuel-lean mixture for combustion in the secondary stage. Numerical predictions using steady-state methods cannot account for the unsteady phenomena

in the mixing region. Therefore, this project addresses a novel unsteady mixing model that can be used to evaluate mixing and combustion, including NO production within the mixing region. This model will be developed for use in conjunction with steady-state prediction methods and thus will have the potential for providing an improved engineering design analysis tool. The capability of this model will be demonstrated in Phase I with the eventual objective of coupling the model to a steady-state solver in Phase II.

Potential Commercial Applications: The model of unsteady mixing in realistic gas turbine combustors can be utilized for a variety of design and analysis work both by the government and by the engine manufacturing industry.

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004 LeRC
90-1-01.02-0875 NAS3-26139
Compact, Gas-Turbine Engine with Effective Turbine-Blade Cooling
Fluidtherm Engineering
169 South Peak Lane, Sugarloaf Road
Boulder, CO 80302
W. Gene Steward (303-444-0875)

This project investigates an innovative compact, configuration of the gas turbine engine that has unusually effective cooling of turbine blades. This could result in higher turbine-inlet temperatures, power, and efficiency than is common in turbines. Because of its inherently low pressure ratio, the engine would be suited to, but not limited to, small scale applications. Phase I will study the effectiveness of blade cooling and the potential benefits of elevated allowable turbine-inlet temperatures and explore the necessity for regeneration in a low-pressure-ratio, gas-turbine engine. If power and efficiency are as enhanced as preliminary estimates would indicate, the engine could compete for many applications now employing much more bulky piston engines. It would be particularly attractive where a high degree of portability is important as in emergency power or pumping stations and vehicle propulsion.

Potential Commercial Applications: Possible applications include efficient, high-output emergency power sources for electricity, vehicle propulsion, or pumps for fire fighting or flood drainage.

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005 LeRC
90-1-01.02-3779 NAS3-26141
Enhanced Diagnostic Methods for Planetary Gear Systems
Technology Integration & Development Group
One Progress Road
Billerica, MA 01821
David R. Levasseur (508-667-3779)

Diagnostic fault detection requires knowledge of failure modes, recognition of measurable fault patterns, and implementation of optimized signal processing. Many of today's rotorcraft transmissions use planetary-gear reduction systems; these systems pose a complex problem in the diagnostics field due to the non-fixed axis gears and bearings present therein. This project will explore methods to increase the fault signal-to-noise ratio for planetary systems though an integrated approach using the hunting tooth period, innovative sensors and sensor locations, structural transmission path analysis, and high frequency data processing techniques. The approach involves development of computer-based models for planetary-gear system performance and fault patterns. In conjunction with the computer models, diagnostic process algorithms will be built to optimize detection of the predicted fault patterns. The algorithms will be tested on data obtained with a gear-box monitoring system. Additionally, hardware requirements for planetary-gear system monitoring will be developed. The resulting advances in planetary gear diagnostics will be integrated with the firm's on-going gear-monitoring research to develop a unified approach to helicopter gear-box monitoring.

Potential Commercial Applications: This technology would augment diagnostic systems currently available.

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006 LeRC
90-1-01.02-5215 NAS3-26140
Novel Catalytic Approach to Combustion
Precision Combustion, Inc.
25 Science Park
New Haven, CT 06511
William C. Pfefferle (203-786-5215)

This project is developing a novel, catalytically ignited, plug-flow combustor that will improve gas turbine performance. Based upon prior SBIR projects and internal research, the project will experimentally test key aspects of this improved catalytic combustor, demonstrating improved operational limits. This new approach to the catalytic combustor offers the potential for plug-flow combustion at high velocity and temperatures along with exceptional multifuel, turndown, and high-altitude re-light capabilities.

Potential Commercial Applications: Commercial applications include combustors for all types of gas turbine engines. Data developed will also be helpful for other applications of catalytic ignition and combustion.

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007 LeRC
90-1-01.02-6576 NAS3-26142
Integration of Combustor Aerodynamics and Fuel Spray to Increase Turndown Fuel-Air Ratio in Small Gas-Turbine Combustors
CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
Clifford E. Smith (205-536-6576)

This project will integrate combustor aerodynamics and fuel spray patterns to attain high turndown ratios without significantly modifying conventional combustor geometry. This will be accomplished by: the creation of two distinct zones within the combustor primary zone that are independently fueled; the use of a dual-lip airblast fuel atomizer that fuels only the central recircu-

lation zone at low power conditions and both the dome and central recirculation zones at full power; and the employment of staggered, widely-spaced, upstream-angled primary holes that allow jet penetration into the dome zone. In Phase I, three-dimensional CFD analysis will be performed on the advanced configuration as well as a conventional configuration. Comparison will be made to show the advanced design's potential of increasing turndown fuel-air ratio without producing excessive smoke emissions. In Phase II, the design would be further optimized. A sector combustor will be designed, fabricated, and tested at various power settings to demonstrate the concept experimentally.

Potential Commercial Applications: The final products of this project would be of interest to manufacturers of gas turbine engines and to government agencies responsible for combustor evaluation.

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008 LeRC
90-1-01.03-1228 NAS3-16145
New, Distributed Fiber-Optic Sensors Based On Counter-Propagating Waves
American Micro-Optical, Inc.
P.O. Box 280
Southbridge, MA 01550
Marcos Kleinerman (508-765-1228)

A novel, fiber-optic approach is taken in this project to the distributed sensing of forces and temperatures simultaneously at different locations with a single long optical fiber probe. This concept uses temperature- and/or force-dependent stimulated light amplification processes at each sensing point along the fiber probe. The approach is designed to generate, at each sensing point along the fiber, optical signals unaffected or only minimally affected by the magnitude of the forces and/or temperatures at other points along the fiber. In contrast to presently known methods, our approach does not require measurements of the state of polarization of the light at any point along the fiber probe, and it should be implementable with relatively simple instrumentation.

Potential Commercial Applications: The system should find applications in the monitoring of the structural integrity of buildings, bridges, pipelines, and aircraft structures, and for implementing effective process control in a wide variety of industrial processes.

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009 LeRC
90-1-01.03-6000 NAS3-26147
Remote, Wireless Monitoring of Positron Escape for Gauging Temperature and Strain
Spire Corporation
Patriots Park
Bedford, MA 01730
Charles C. Blatchley (617-275-6000)

This project will investigate the monitoring of strains and temperatures based on the unique electrical properties of positrons at metal surfaces. Unlike bound electrons, positrons are often actively expelled from metals due to a net negative work function that can be sensitive to strain or temperature. Sources can be inexpensively created inside a metal component by accelerator activation. The fraction of positrons leaving the surface would be affected by a number of strain or temperature sensitive variables such as work function, defect density, grain-boundary size, and conductivity. Thus, monitoring of annihilation gamma rays away from the activated surface will indicate strain or temperature as in conventional sensors but at much higher temperature and with none of the disadvantages that characterize electrical or optical fiber connections. This would be ideal for operating high-temperature engines, particularly on rotating parts. Refractory materials could be used at extremely high temperatures, over 2000°C. Rapidity of measurement would be a function of source strength, but quite modest sources that do not involve any hazard or special handling could produce reliable measurements every 10 to 20 seconds.

Potential Commercial Applications: Wireless, high-temperature gauges would have widespread application in advanced engine testing and development.

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010 LeRC
90-1-01.04-0003 NAS3-26146
Laser-Driven Hypersonic Airbreathing Propulsion Simulator
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Prakash B. Joshi (508-689-0003)

This project addresses a novel concept for incorporating propulsive effects into wind tunnel testing of hypersonic aircraft models. The concept involves using a laser beam to add heat to the airflow entering the aircraft's power plant, a ramjet engine. The beam, which may be from a continuous wave or a repetitively-pulsed laser, enters the nozzle and is focused at a spot. Heat transfer occurs due to absorption of energy at laser wavelengths into the gas. It is envisioned that a commercially available CO_2 or other similar lasers will be suitable for current applications. It appears plausible to produce thrust of one engine for a 1/100th scale model of a typical multi-engine hypersonic vehicle without requiring prohibitive laser power levels. If the concept is shown to be feasible and can be demonstrated experimentally, a significant new dimension will be added to the utility of high-speed wind tunnels. A simultaneous experimental simulation of aerodynamic and propulsion (or propulsion-induced) effects will become possible.

Potential Commercial Applications: The simultaneous experimental simulation of aerodynamics and propulsion, particularly the effects on aircraft drag, will add a new dimension to wind-tunnel test methodology.

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02: Aerodynamics and Acoustics

011 ARC
90-1-02.01-2027 NAS2-13365
Solution-Adaptive Gridding within the Chimera Grid Scheme
Chimera Research
P.O. Box 421777
Del Rio, TX 78842-1777
F. Carroll Dougherty (512-298-2027)

This project is concerned with the development of a computational tool that combines solution-adaptive techniques with an overset grid technique to solve unsteady aerodynamic problems in such areas as powered lift, helicopter-wake resolution, and high- alpha, enhanced maneuverability aircraft. Both techniques have been used to attempt to simplify the task of generating efficient meshes for computational simulations, but grid generation remains an obstacle to quick, accurate flow-field simulations. The coupling of these two techniques would allow for faster, more accurate grid generation, as well as general purpose grids that would be well-suited for a range of flow-field conditions. This would greatly reduce the need to compute new grid systems for each new set of flight conditions. In addition, a particular aspect of the Chimera scheme that can allow relative motion between grids can be utilized by the solution-adaptive technique to comput time-dependent adaptations.

Potential Commercial Applications: Military and commercial aircraft designs for such aircraft as high maneuverability fighters, powered-lift vehicles, and helicopters would be improved with the advanced simulation capabilities developed in this effort.

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012 ARC
90-1-02.01-9500 NAS2-13354
A New, Subgrid Model for Large-Eddy Simulations of Mixing and Chemical Reaction in Turbulent Flows
Quest Integrated, Inc.
21414 68th Avenue South
Kent, WA 98032
Suresh Menon (206-872-9500)

Conventional, turbulent-mixing models based on gradient-diffusion assumptions are not capable of accurately predicting mixing and reaction rates in most practical combustion devices. Furthermore, at the small scales, most conventional models make no distinction between turbulent conversion and molecular diffusion. This distinction is critical for the accurate description of the mixing process. In addition, it is known that turbulent mixing and entrainment processes in shear flows are dominated by unsteady, large-scale, vortical motions. The spatial and temporal evolution of these large-scale structures cannot be modeled and must be explicitly computed for accurate predictions. Phase I will explore subgrid modeling techniques for use in large-eddy simulation (LES) of reacting flows. In particular, a model for mixing and chemical reactions at the subgrid level in both low- and high-speed flows will be developed based on Kerstein's linear-eddy approach. LES of incompressible, two-dimensional mixing layers will be performed, and the results will be compared with high-resolution, direct numerical simulations and available experimental data to assess the proposed subgrid model. This model would be extended to study three-dimensional, compressible reacting flows with heat release in Phase II.

Potential Commercial Applications: A predictive capability for unsteady simulation of combustion in both low- and high-speed flows with full coupling between the chemical heat release and the fluid dynamic flow field can be utilized for a variety of purposes by both government and industry.

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013 LaRC
90-1-02.02-9457B NAS1-19256
Nonlinear Control of Shear Flows
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Laurence R. Keefe (415-968-9457)

Chaos theory has recently suggested two innovative strategies for active control of general, nonlinear systems. Both are potentially applicable to the problem of controlling shear flows, whether it be to enhance or suppress the effects of turbulence. Each makes essential use of the nonlinear character of the system to obtain control. In model studies of nonlinear oscillators, control by one of these methods has already produced dramatically better results then traditional linear methods. The question of whether these control schemes be made to work in bounded and unbounded shear layers will be addressed by this project. Work will be done to determine the feasibility of their application, to judge the suitability of each method in closed and open flows, to suggest guidelines for their implementation, and to test them both on a model problem that can display the mathematical character of either fully developed or transitioning flows. Success in this research would point the way to development and testing of nonlinear flow control schemes capable of substantial skin-friction and heat-transfer reductions at walls and mixing enhancement in shear layers and jets.

Potential Commercial Applications: A practical flow control system that could decrease drag, heat transfer, and structural vibration; increase payloads and propulsive efficiency; and enhance maneuverability would have substantial impact on the economics of commercial flight operations.

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014 LaRC
90-1-02.03-1806 NAS1-19270
Hypervelocity Launcher for Aerothermodynamic Experiments
IAP Research, Inc.
2763 Culver Avenue
Dayton, OH 45429-3723
David P. Bauer (513-296-1806)

The development of hypersonic aerospace vehicles requires detailed knowledge of the aerothermodynamic (ATD) environment in which the vehicle will be operated. Experimental study of ATD parameters at greater than 6km/s is presently not feasible. The goal of this project is to develop the technology base and demonstrate an electromagnetic gun system capable of achieving greater than 6km/s launch velocity. The object is to develop a distributed, energy-storage concept for powering railguns to push the system energy conversion efficiency to more than 80 percent. This high efficiency at hypervelocity will make ATD testing at greater than 6km/s feasible.

Potential Commercial Applications: There are several potential applications of launchers capable of reaching >10km/s. These include impact fusion, equation-of-state testing, and earth-to-space launch.

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015 ARC
90-1-02.03-3013 NAS2-13367
Innovative Model for Reacting Flows
Hypersonics, Inc.
164 Ferne Court
Palo Alto, CA 94306-4607
Raul J. Conti (415-856-3013)

This project explores the benefits of a new computational model for reacting flows. It applies to nonequilibrium flows, in general, but is specially designed to address the frequent condition in hypersonic flows where some of the reactants are near thermochemical equilibrium, while the remainder are out of local equilibrium. Nonequilibrium flows are present in several vehicles of interest to NASA, including future space shuttles, the national aerospace plane, hypersonic transportation, aerobraking orbital transfer vehicles, and planetary probes. Numerical methods to compute nonequilibrium flows involving a moderate-to-large number of reactants are costly to operate and can benefit substantially from simplifications; in some cases such simplifications are key to the practical feasibility of the computations. This investigation consists of exploring a new, mixed, equilibrium-nonequilibrium model based on past experience with magneto-hydrodynamic channel flows, and testing it numerically under hypersonic flight conditions to assess its potential pay off for Phase II development and validation.

Potential Commercial Applications: None Provided.

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016 MSFC
90-1-02.04-3304 NAS8-38892
Hypersonic Analysis for Vehicles in the Continuum-Transition Regime
Amtec Engineering, Inc.
3055 112th Avenue N.E. #208
Bellevue, WA 98004
Scott T. Imlay (206-827-3304)

Several aerospace vehicles are currently being considered that have a significant portion of their flight path in the upper reaches of the atmosphere. The flow about these vehicles is in the continuum-transition regime where the standard equations of continuum flow, the Navier-Stokes equations, begin to fail. This project will modify the HANA code, an existing Navier-Stokes code for the analysis of hypersonic vehicles, to solve the Burnett equations with coupled, rotational nonequilibrium. The Burnett equations are more accurate than the Navier-Stokes equations for low-density flows with finite thickness shocks. Solutions to the Burnett equations have only recently been obtained for the hypersonic flows. The Phase I investigation will determine the viability of solving the Burnett equations with coupled, rotational, nonequilibrium and surface-slip boundary conditions within the HANA code. In particular, the ramifications of using upwind differencing of the inviscid fluxes and diagonalized viscous Jacobians in the LU-SGS implicit method will be studied. The proper implementation of surface-slip boundary conditions will also be considered.

Potential Commercial Applications: A Burnett equation code will benefit existing and future hypersonic vehicle development programs within government and the aerospace industry.

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017 MSFC
90-1-02.04-8581 NAS8-38887
Rarefied Gas Effects On Aerobraking/Reentry Vehicles with Wakes
Remtech, Inc.
3304 Westmill Drive
Huntsville, AL 35805
A. C. Jain (205-536-8581)

Aerobraking vehicles (AOTV, ASTV and vehicles to Mars) are going to make several passes and dip low in the transitional regime in order to achieve the desired reduction in velocity. Even at the lowest point of the trajectory, surface-slip effects persist and real-gas effects due to nonequilibrium dissociation and ionization significantly alter the flow structure. Further, due to impingement of the shear layer on the vehicle payload, it has become imperative to investigate accurately the complete flowfield with wake closure on the vehicle in the presence of slip and real-gas effects. This project will investigate the hypersonic-rarefied flow phenomena on a complete body including wake with slip and real-gas effects from the upper rarefied region to the lower continuum region of the transitional regime. This will be accomplished by incorporating in the mathematical analysis of the Navier-Stokes equations with slip, an adaptive grid-generation technique that will accurately resolve the shock structure zone and the highly viscous region near the surface. In Phase I, a suitable, adaptive-grid generation technique will be incorporated in the mathematical model of the stagnation line flow. In Phase II, the computational algorithm developed in Phase I would be applied to predict the complete flowfield with wake closure on bodies of arbitrary shape.

Potential Commercial Applications: This computer code would provide to the designer of space vehicles vital information about the aerothermal environment of an

aerobraking/reentry-type vehicle with wake in the complete transitional regime.

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018 MSFC
90-1-02.05-0003 NAS8-38885
Effects of Supercooling and Melt Phenomena on Particulate Radiation in Plumes
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
W. T. Rawline (508-689-0003)

In the evaluation of heat loading due to radiation emitted by particles in a solid rocket plume, the effects of particle supercooling on the submelt radiative characteristics are not well understood. This project will experimentally characterize this supercooling phenomenon by observing particle radiation during the rarefaction wave cooling of shock-heated Al_2O_3 particles. The Phase I effort will provide NASA with quantitative data for the effects of supercooling on the optical properties of Al_2O3, and will define potential Phase II efforts to quantify other high-temperature radiative effects and to develop experimental concepts for verification of predictive codes. The innovative aspects of the work lie in the use of the rarefaction wave in a shock tube to simulate plume supercooling effects and in the application of state-of-the-art optical diagnostics to determine refractive indices of particles at high temperatures.

Potential Commercial Applications: The diagnostic techniques and data bases would be relevant to the solid rocket motor industry.

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019 MSFC
90-1-02.05-2008 NAS8-38922
Radiation from Advanced, Solid Rocket Motor Plumes
Seca, Inc.
3311 Bob Wallace Avenue, Suite 203
Huntsville, AL 35805
Sheldon D. Smith (205-534-2008)

Thermal loads created by the plumes of advanced solid rocket motors are not predictable; such loads are currently obtained from experiment. Test data are correlated by postulating plume temperature, shape, and emissivity; and heating rates are calculated with appropriate view factors from this simplistic plume model. Although other extensive relevant technology has been developed to describe infrared signatures and to calculate plume flowfields and non-grey, scattering radiation, such technology cannot yet provide accurate base-heating estimates. This project will develop a prediction method for quantitatively evaluating the thermal radiation from solid rocket motors that does not require any subsidiary test data. Verification would be accomplished with existing data, so that the method could be used as a design tool for evaluating radiation base heating for advanced, solid rocket motor configurations.

Potential Commercial Applications: A preliminary design tool for predicting radiative heating from advanced solid rocket plumes would be used by NASA, DOD, and/or their prime contractors to analyze plume heating for IR decoy design studies.

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020 ARC
90-1-02.06-3304 NAS2-13357
A Zonal Method for Modeling Powered-Lift Aircraft Flow Fields
Amtec Engineering, Inc.
3055 112th Avenue N.E. #208
Bellevue, WA 98004
Donald W. Roberts (206-827-3304)

Advanced short takeoff/vertical landing aircraft are designed to use exhaust jets directly to increase lift. Being able to model numerically the flow fields involved in these designs would greatly improve the design process. This project will develop a cost-effective flow analysis tool for modeling powered-lift aircraft flow fields. A key ingredient in the development of a practical flow analysis is the turbulence model. The Phase I objective is to develop and validate a turbulence model that will accurately and efficiently model the turbulence phenomena in flows with the strong curvature encountered in powered-lift flows. A two-equation model coupled to an algebraic Reynolds stress model will be investigated in the context of a three-dimensional Navier-Stokes code. A sub-grid-scale model will also be examined. The models will be tested by calculating a jet in ground effect with a crossflow with particular attention on the ground vortex.

Potential Commercial Applications: This flow analysis tool would be directly applicable to the design and evaluation of powered-lift aircraft concepts.

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021 ARC
90-1-02.06-8228 NAS2-13302
A Multiple Component Force-and-Moment Balance for Water Tunnel Applications
Eidetics International, Inc.
3415 Lomita Boulevard
Torrance, CA 90505
T. Terry Ng (213-326-8228)

The development of a multi-component, force-and-moment balance for applications in low-speed flow visualization water tunnels is the goal of this project. The balance will allow detailed flow visualization and force-and-moment measurements to be performed simultaneously in a water tunnel, thus providing quantitative information prior to wind tunnel tests. In addition to saving time and cost of testing, uncertainties associated with differences in models, facilities, and test conditions are eliminated. The balance can also provide a capability for complicated dynamic measurements that are difficult to perform in a wind tunnel. The long-term objective is to develop and test a six-component force-and-moment balance system and related calibration equipment that can be manufactured and produced commercially for other water tunnel users in this country and abroad. The primary goal of Phase I is to develop preliminary designs for various components of a force-

and-moment balance. Major improvement and refinement efforts would be carried out in Phase II to develop and construct a prototype of a final design, and extensive static and dynamic tests will be performed to verify the performance of the system and to develop techniques for various applications.

Potential Commercial Applications: Present water tunnel users in the U.S. and abroad need to conduct force-and-moment measurements in their tunnels. A balance capable of performing static and dynamic force-and-moment measurements should greatly increase the interest and demand for water tunnels.

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022 LaRC
90-1-02.06-8228A NAS1-19289
Aerodynamic Control of Aircraft Using Miniature, Rotatable Nose-Boom Strakes
Eidetics International, Inc.
3415 Lomita Boulevard
Torrance, CA 90505
T. Terry Ng (213-326-8228)

The goal of this project is an innovative method of enhancing the controllability of aircraft at moderate-to-high angles-of-attack (AOA) by controlling the forebody vortex flow with rotatable nose-boom strakes. The idea is to control the asymmetry of the nose-boom wake by placing small, movable strakes on the nose-boom. The wake then acts as a controlled perturbation on the forebody flow and subsequently dictates the form of the forebody vortex asymmetry. A preliminary, water-tunnel study demonstrated that the concept is highly promising. The nose-boom strakes provide effective controls on the forebody vortices for AOAs from approximately 25° to 60° or above. Thus control forces may be generated to augment the controls presently available on the F-16 or other aircraft to allow the full capability of the aircraft to be utilized. The innovative system can potentially be very small in size, relatively easy to implement and operate, and effective over wide ranges of angles-of-attack and sideslip.

Potential Commercial Applications: This control system could be retrofitted to existing aircraft and/or incorporated in the ones in future production.

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023 LaRC
90-1-02.09-2701 NAS1-19280
A Novel, Polarization-Preserving, Fiberoptic Sensor for High-Temperature Environments
Quantex Corporation
2 Research Court
Rockville, MD 20850
Dong X. Yu (301-258-2701)

This project investigates a novel, fiberoptic sensor for high-temperature environments in which each eigenstate in a polarization-preserving fiber forms an interferometer to sense the temperature and the other causes of optical-path-length changes, such as strain and pressure. This fiberoptic sensor has the potential for superior performance in high-temperature environments as compared to the dual-wavelength fiber sensor.

Potential Commercial Applications: Many fields could be explored for potential applications such as automobiles, aircraft, production lines, and construction.

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024 LaRC
90-1-02.09-7500 NAS1-19269
High-Resolution, Optical, Multichannel Transducer Array for Wind Tunnel Applications
Interscience, Inc.
105 Jordan Road
Troy, NY 12180
James Castracane (518-283-7500)

For the accurate analysis of wind-tunnel modeling, it is necessary to have precise measurements of the pressure profiles over the model surface to understand the effects of short-scale-length turbulence. A durable transducer array capable of spatially resolved, real-time pressure measurements will be developed. The innovative features of the optical, multichannel transducer array (OMTA) are two-fold. First, the signals are based on optical effects for fast response and high-resolution. Second, the transducer array will be fabricated using semiconductor manufacturing techniques and will be coated with diamond-like films for protection against high-temperature, corrosive wind-tunnel conditions. Through the use of such a system, high temporally and spatially resolved measurements may be made in hostile environments. The importance of this innovation is its impact on aerospace research and in particular, as a powerful new diagnostic for wind-tunnel studies on scale models.

Potential Commercial Applications: This transducer system could be marketed as a finished product to be applied to harsh-environment sensing such as automobile engines or combustion facilities.

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025 LaRC
90-1-02.10-4400 NAS1-19271
Adaptive, Nonlinear, Polynomial Networks for Rotorcraft Cabin Noise Reduction
Barron Associates, Inc.
Route 1, Box 159
Stanardsville, VA 22973-9511
Roger L. Barron (804-985-4400)

To reduce rotorcraft-cabin noise and vibration via active anti-sound techniques this project investigates adaptive, nonlinear, polynomial network-prediction and noise-cancellation algorithms In recent years, there has been a considerable amount of work on the use of statistical signal-processing techniques to produce anti-sound acoustic fields for reducing vibration and noise in enclosed spaces. These basic techniques employ adaptive linear prediction algorithms to the noise field, as sensed from an array of speakers, to cancel the predictable part of the noise in the array. The adaptive linear prediction and control methods used in the reduction of cabin noise for propeller-driven aircraft

appear to be quite successful. Although the noise field produced by a propeller can be well-modeled as a Gaussian process (and thus linear prediction is optimal), rotor noise typically has significant impulsive components and cannot be well-modeled as a Gaussian process. Therefore, nonlinear predictors are needed to achieve the desired cabin-noise reduction. The Phase I work emphasizes the development of polynomial network predictor architectures to minimize the noise residuals from an array of sensors within the cabin. In Phase II, a more detailed multiple-error, noise-abatement system will be designed and evaluated using actual rotorcraft data.

Potential Commercial Applications: This work could be applied to noise reduction in aircraft cabins and vibration reduction in airframes. In a more general context, the modeling and processing techniques could be applied in nonlinear signal-processing for speech processing, data transmission, and seismic signal processing.

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026 LeRC
90-1-02.11-8610 NAS3-26143
Gas Turbine Noise Reduction
Altex Technologies Corporation
650 Nuttman Road, #114
Santa Clara, CA 95054
John T. Kelly (408-980-8610)

Reduction of gas turbine propulsion system noise, and associated vibrations, is an important goal for future aircraft. The objective of this project is to use an innovative methodology to identify and quantify the primary source of noise in gas-turbine combustors and use the results to identify a high-potential, noise-avoidance concept. An innovative unsteady flow model will be used to identify and quantify the fluid-dynamic source of noise, small-scale experiments will be run to confirm the model results, and noise-avoidance concepts will be identified and ranked. A best concept will then be selected and recommended for further development under a Phase II effort.

Potential Commercial Applications: The use of this concept in commercial and military aircraft will reduce noise and vibration impacts on aircraft, improve their reliability and reduce maintenance costs.

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03: Aircraft Systems, Subsystems, and Operations

027 LeRC
90-1-03.01-0533 NAS3-26154
Shape Memory Alloys for Use in Rotorcraft De-Icing Systems
Innovative Dynamics
244 Langmuir Lab, Cornell Research Park
Ithaca, NY 14850-1296
Joseph J. Gerardi (607-257-0534)

Increased readiness and safety demands being made on helicopters require an all-weather capability. While several promising de-icers have been developed for fixed wing aircraft, the requirement still exists for a reliable de-icing system compatible with helicopter blades. The ideal de-icer must be small, require a minimum amount of interface hardware, and be able to operate efficiently on low power/voltage and to survive leading-edge-erosion effects. This project will develop a unique ice protection system that is based on the capability of shape memory alloys (SMA) to change dimension rapidly and reversibly when current or heat is applied. Several methods to induce the shape memory effect, including inherent resistive heating of the SMA or heat transfer from an attached thermal couple or conventional electrothermal de-icing coil will be investigated. Mechanical debounding is expected to take place in seconds versus minutes using only a fraction of the power required for thermal debounding. Helicopter blades may be the ideal application for shape memory de-icers because of the small leading-edge area and availability of convective cooling to induce martensitic transformations. Phase I includes design and test of a SMA helicopter-blade de-icer prototype for evaluation of leading-edge ice debonding performance.

Potential Commercial Applications: A shape memory alloy de-icing system may be well suited for use on marine vessels and advanced commercial transports.

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028 LaRC
90-1-03.02-1400 NAS1-19250
Pilot Wx Advisor
Vigyan, Inc.
30 Research Drive
Hampton, VA 23666-1325
Arun K. Gurjale (804-865-1400)

The safety of flight operations of many general aviation (GA) aircraft is compromised by the lack of real-time, severe-weather information in the cockpit. This project will develop and demonstrate an automated cockpit weather-display system that will do all these things and more. In Phase I, the ability of modern communication systems to put large amounts of weather data derived from ground observing sites on board a GA aircraft will be evaluated. Demonstration flight tests will be conducted to show the feasibility of a satellite communication link and the prototype map-type weather depictions. A prototype airborne system would be constructed and tested on a high-performance GA aircraft in Phase II. Additional data types will be considered, including area forecasts and trends, route cross-sections, TDWR, and NEXRAD products, if available, on an electronic, moving-map display. These additional data types will be used as input to an on-board smart system that would develop flight path recommendations based on the pilot's own operational criteria.

Potential Commercial Applications: The potential market for a state-of-the-art cockpit weather display is conser-

vatively estimated to be 5000 units for existing aircraft, and 400 to 500 units a year for new production.

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029 LaRC
90-1-03.03-2233 NAS1-19261
Ideal Flying Qualities for Aero-Space Craft
Systems Control Technology, Inc.
P.O. Box 10180
Palo Alto, CA 94303
Mark R. Anderson (301-863-5077)

There is currently considerable interest, both in the U.S. and abroad, in the development of aircraft capable of hypersonic flight. However, there is very little guidance available on the flying qualities characteristics that are desirable for this class of vehicles. This project will attempt to determine the most ideal set of flying qualities characteristics by using a key result of integrated control-system technology. Future hypersonic aircraft will no doubt require the use of a control system that will integrate the aircraft's aerodynamics, propulsion, and stabilization systems. Using an integrated, model-following control system, it is possible to make the aircraft response match that of a chosen command model. Therefore, this project will seek for the optimal command model for hypersonic aircraft. This innovative approach is in direct contrast to the traditional method of closing one control-loop at a time until "acceptable" flying qualities are achieved. The Phase I work will focus on a review of current, applicable flying qualities criteria, construction of a preliminary command-model, and development of a simulation test plan. The Phase I work will serve as preparation for a real-time, piloted simulation of the command model dynamics in Phase II.

Potential Commercial Applications: Commercialization of the ideal command model description will result from technology transfer to airframe manufacturers currently interested in developing manned, hypersonic aircraft through marketing software for comparison of vehicle characteristics to the ideal.

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030 ARC
90-1-03.04-7300 NAS2-13358
Visual Motion for Rotorcraft Guidance
Advanced Decision Systems
1500 Plymouth Street
Mountain View, CA 94043-1230
Philip Kahn (415-960-7457)

For rotorcraft in a nap-of-the-earth (NOE) flight regime, collision with wires presents a significant threat to safety. Wire detection and avoidance is thus an important part of safe NOE guidance. Wire detection can be difficult: wires are often not strongly spatially evident, dangerous wires often occur at the focus-of-expansion (FOE), there is often significant background clutter and noise, and the detection task is on-going and must be fast enough to permit evasive maneuvers. This effort examines innovative wire-detection and tracking techniques that address these issues. Wires are treated as moving edges in densely sampled imagery, and these edges are then tracked using local computational mechanisms that are amenable to fully parallel implementation with VLSI to improve tracking and compute motion properties, tracker-control methods that integrate numeric information from known parameters of camera motion produced by gyros with symbolic and rule-based information based upon aggregates of image features will be explored. These tracked edges provide important descriptions of moving wires (e.g., measures of stability and motion) that can be used for avoidance and guidance.

Potential Commercial Applications: An automated wire-avoidance system has direct applicability for commercial air traffic safety. This project also provides a basis for developing advanced, vision-guided robotic capabilities.

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031 ARC
90-1-03.05-3636 NAS2-13301
A Compact, Optical Air-Data System for Flight Test Applications
Optical Air Data Systems - L.P.
P.O. Box 7836
Van Nuys, CA 91409
Philip L. Rogers (818-997-3636)

An innovative, electro-optical, primary, air-data system concept that will provide accurate airspeed, angle-of-attack, and angle-of-sideslip information will be evaluated. Patented technology will allow a compact, lightweight, eye-safe-laser velocimeter system to be constructed for airborne use. Phase I of the program will involve preliminary flight testing of an existing proof-of-concept prototype unit to establish suitability as a primary, air-data flight-test instrument. Phase II will expand the flight envelope into the supersonic and high-angle regimes with a fully capable prototype system.

Potential Commercial Applications: In addition to flight-test measurement applications, this technology is valuable in both commercial and military markets as both a primary, air-data system for high-performance aircraft as well as a "look-ahead" wind-shear detector.

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032 ARC
90-1-03.05-6100 NAS2-13306
In-Flight Flow-Velocity Sensor
Deacon Research
2440 Embarcadero Way #B
Palo Alto, CA 94303
David Deacon (415-493-6100)

Existing airspeed sensors are bound to the airframe surface and sample the flow within the bow-wave perturbation zone where airspeed and angle-of-attack information are intermixed. This innovation combines recently developed technologies that enable flow measurements off the airframe surface in the freestream beyond the bow-wave. Narrow-band diode laser technology coupled with high-power laser diodes and an innovative, double-heterodyne detection system enables measurement of the Doppler shift of the laser light backscattered from the aerosol content of the atmosphere. Three such sensors can be used to determine

the magnitude and vector direction of the air velocity, yielding both airspeed and angle-of-attack. with a small addition in electronics, an ice/snow discriminating detector could also be added to the system to warn of dangerous levels of ice crystals in the freestream. This system will be all-solid-state and, therefore, compact, efficient, and rugged enough for the inflight application. The available dynamic range extends from low speed to Mach 18, depending on the electronics design. The Phase I objective is to measure the signal-to-noise ratio of a bread-board system.

Potential Commercial Applications: After initial use in flight testing to establish airframe performance envelopes, the sensor, if the cost is low enough, could be used in general commercial aviation to optimize fuel usage.

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033 ARC
90-1-03.05-8100 NAS2-13305
Non-Intrusive, Boundary-Layer Transition Frequency Detector
Aptek, Inc.
1257 Lake Plaza Drive
Colorado Springs, CO 80906-3578
Anthony W. Raskob Jr. (719-576-8100)

A non-intrusive, boundary-layer transition detector that can indicate the presence of local transition and provide information on the frequency components of the flow will be developed. The design concept is an adaptation of a transition detector used successfully in ballistic-missile reentry-vehicle flights. The work will demonstrate concept feasibility on flight skins of present interest to NASA. A study will be performed to provide data for modeling the transitional and turbulent boundary layer pressure spectrum. An evaluation of acoustic noise sources which may affect gage performance and a method for addressing them will be made. A preliminary heat-resistant design will be constructed and tested in the laboratory for localized and frequency response. Methods for improving gage ability to respond to only local signals will be identified. A flight test program will be specified for evaluating gage performance in a NASA field testing.

Potential Commercial Applications: This gage would be useful instrumentation for transition experiments or any turbulent boundary-layer experimentation. Such development as the National Aero-Space Plane and Supersonic Transport could use the device to monitor the success of transition-delaying techniques.

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034 ARC
90-1-03.06-0321 NAS2-13300
Compact, Rugged, Laser-Doppler Velocimeter Probe for In-Flight Gas-Turbine-Inlet Flow Measurement
Aerometrics, Inc.
894 Ross Drive, Unit #105
Sunnyvale, CA 94089
William D. Bachalo (408-745-0321)

Measurements of the inlet flow fields of aircraft propulsion systems are important in defining the thrust and efficiency of these engines as well as in flight safety when executing avoidance maneuvers. This project will develop a non-intrusive laser-doppler velocimeter (LDV) probe that is compact and rugged enough to perform these measurements in flight. This LDV probe will replace the more intrusive and bulky material probes currently in use. Mapping the inlet flow velocity will allow more accurate measurement of in-flight thrust as well as aid in the understanding of inlet stall and separation. This probe is only now possible with recent developments in fiber optics and frequency-domain signal processing. This project involves the definition, design, and preliminary testing of an innovative probe to measure these inlet flow fields. Size discrimination of seeded particles will be included so that atmospheric aerosols can be used as seed particles. Testing of the prototype probe will be conducted both in simulated and ground-tethered flow fields.

Potential Commercial Applications: Beyond the measurement of inlet flow field of gas engines, this has commercial applicability to numerous other flow fields such as power plants, rocket engines, and virtually any fluid-dynamic flow with harsh conditions.

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035 LaRC
90-1-03.07-0236 NAS1-19285
Carbon-Carbon, Refractory Metal Heat Pipes for Leading-Edge Cooling on Reusable Hypersonic Vehicles
Ultramet
12173 Montague Street
Pacoima, CA 91331
Richard B. Kaplan (818-899-0236)

Reusable hypersonic vehicles, operating well beyond the performance envelope of conventional aircraft, will encounter extremely high temperatures; during reentry, the nose will experience in excess of 5000°F, and leading-edge surfaces will feel nearly 3500°F. Clearly, lightweight leading-edge cooling concepts are needed to withstand such high temperatures. The heat pipe--a quasipassive, self-contained, low-maintenance device--should be well-suited for leading-edge cooling applications. This Phase I project will demonstrate the feasibility of fabricating a straight D-shaped heat pipe by chemical vapor deposition (CVD) and infiltration (CVI). The wick will be a refractory-metal-infiltrated carbon foam, and the container walls will be a thin refractory metal skin or shell. Compatibility of the chosen refractory-metal with carbon-carbon will be established, and a CVD technique for producing container walls of minimum thickness for weight reduction will be defined. At the end of the project, the heat pipe will be filled with a working fluid and tested for isothermal operation. The result will be the definition of techniques for fabricating actual leading-edge heat pipe configurations in Phase II and beyond.

Potential Commercial Applications: Heat pipes of lightweight, refractory metal heat pipes would be useful for

the wing leading-edges of reusable hypersonic vehicles such as the NASP.

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036 ARC
90-1-03.08-9983 NAS2-13360
Passive Propeller Control
Aerovironment, Inc.
P.O. Box 5031
Monrovia, CA 91017-7131
P.B.S. Lissaman (818-357-9983)

Very-high-altitude, long-endurance (VHALE) type aircraft operate over a wide power range due to altitude and fuel load changes. Matching the propeller to the engine over this range is difficult without a complicated variable-pitch propeller or gearing. Passive, optimal-pitch control is the goal of this project. The concept consists of an aerodynamically tailored blade, balance weights, and torsionally soft spar mounted on the main propeller shaft and attached to the blade at a point near its mid-span. This eliminates most or all of the linkages and bearings normally needed in a variable pitch mechanism, achieving substantial weight savings and increased reliability. The problem of simple inertial, aero-elastic control is that, over a wide operating range, the required setting is difficult to achieve passively. A method for the multi-point optimal design of passive pitch control propellers that deals with the matching problem will be applied. The tasks include determining design requirements, developing a computer design method for the blade pitch dynamics, exercising the method to design a specific passive-pitch propeller mechanism, and evaluating and documenting the merits of this concept.

Potential Commercial Applications: Applications of the design concept and methodology would be in VHALE and other UAV and light plane applications.

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037 LaRC
90-1-03.09-1457 NAS1-19267
Knowledge-Based Tools for the Conceptual Design of Human-Machine Systems
Search Technology, Inc.
4725 Peachtree Corners Circle, Suite 20
Norcross, GA 30092
William B. Rouse (404-441-1457)

While current technology has made the automation of many crew functions feasible, human capabilities, limitations, and preferences may make automating certain functions undesirable. Designers initially make function-allocation decisions during the conceptual design of human-machine systems. There are currently no knowledge-based tools available that support the designer in making these decisions. These decisions define the nature of the human's role in the system and determine the potential performance levels that can be achieved with the system. A large percentage of the life-cycle costs of a system are also determined by decisions made during conceptual design. The design tools to be developed in this project will support the designer in defining and allocating the system's functions; evaluating the human's functions and tasks by examining the human capabilities, limitations, and preferences; and suggesting methods for overcoming the limitations and enhancing the capabilities of the human. This effort will determine the nature of the support that the designer needs, identify design and knowledge representations for the tools, and develop a scripted prototype to demonstrate and evaluate the tools.

Potential Commercial Applications: Knowledge-based tools that support the conceptual design of human-machine systems have the potential for wide application in aviation, manufacturing, process, and power industries.

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038 ARC
90-1-03.09-2691 NAS2-13359
Applying Recognition-Primed Decision-Making to Man-Machine Interface Design
Klein Associates, Inc.
P.O. Box 264
Yellow Springs, OH 45387-0264
Gary A. Klein (513-767-2691)

Flight-mission operations can require decision-making under conditions--time pressure, psychological stress, poor information, uncertain communications--that make careful analysis difficult. Recent research on strategies of experienced decision makers in complex operational tasks has generated such descriptive accounts as the recognition-primed decision (RPD) model that show why prescriptive decision support systems (DSS) are poorly received in the field. Under pressure, experts use experience to generate a likely course of action. The goal of this project is to build on recent research with the RPD model for designing more effective DSSs and man-machine interfaces (MMI). It should also generate three sets of engineering design principles, one for identifying the critical decisions within a mission, a second for defining the boundary conditions of different decision strategies, and the third addressing the use of the RPD model for DSS and MMI design.

Potential Commercial Applications: The research could apply in a variety of domains (e.g., air-traffic control, process control, aviation) where there are needs for operators to respond quickly to emergency conditions.

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039 ARC
90-1-03.10-7212A NAS2-13304
Applications of Artificial Intelligence to NASP
G & C Systems, Inc.
30250 Rancho Viejo Road, Suite B
San Juan Capistrano, CA 92675
David M. Tartt (714-248-7212)

This project explores the applicability of expert system technology to the National Aero-Space Plane (NASP). It will investigate the feasibility of developing real-time, cooperating, distributed expert systems executing in either on-board or ground-based computers (or both) to perform a variety of functions. The functions include mission planning (including real-time replan-

ning); system monitoring, diagnostics and management; and trajectory management and control. Prudent application of this branch of artificial intelligence to NASP will improve the platform's operational versatility, adaptability, and effectiveness. Specific potential improvements include an on-board capability of adjusting a mission plan in real-time in response to a system failure or degraded performance, an on-board capability of monitoring and providing diagnostics for NASP subsystems, and preflight planning based on the automated flight-test management system. Expert-system technology is particularly suited to abort-trajectory management, propulsion-system monitoring and diagnostics, and flight-test planning.

Potential Commercial Applications: Extensions of this work could apply to planet-surface and atmospheric explorers such as the Mars Rover, military reconnaissance vehicles, and others.

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040 ARC
90-1-03.11-1679 NAS2-13303
A Finite-Element, Heat-Transfer Analysis System for Simulation of Flight Vehicles
Engineering Systems Simulation
12914 Wolverton Lane
Cerritos, CA 90701-7265
C. J. Parekh (213-865-1679)

Predicting the performance of a hypersonic aerospacecraft such as the National Aero-Space Plane (NASP) is difficult because of current technological limitations. Wind tunnels to run high Mach flights to get data on airflow, roll rate, and shock structures are not available. Numerical simulation based on the finite-element solution technique offers a viable, rapid, accurate approach for predicting flight characteristics needed for design, for interpreting flight-test results, and for ensuring safety during flight-envelope expansion. Such flight characteristics are highly nonlinear and complex due to inherent interactions of several constituent disciplines such as structures, heat transfer, materials, fluid dynamics, controls, propulsion, and others. Further, the relevant analysis requires extensive supercomputing effort. Consequently, several essential disciplines as well as efficient solution techniques will be incorporated in an integrated, vehicle-flight simulation system. Phase I activities will focus on developing methodologies for nonlinear heat-transfer simulation capabilities. The development of a complete heat-transfer analysis system as well as efficient algorithms for capturing shocks, separated flows, and vortices in hypersonic flows and adaptive, automatic mesh-generation techniques will be addressed in Phase II.

Potential Commercial Applications: An integrated numerical simulation system can be used to solve a wide spectrum of problems in almost all branches of engineering including aerospace, civil, mechanical, electrical, automotive, petrochemical, bio-medical, and space engineering.

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04: Materials and Structures

041 MSFC
90-1-04.01-8122 NAS8-38907
Solution-Adaptive Code for Analysis of Fatigue-Crack Propagation in Aerospace Structures
Huntsville Sciences Corporation
3315 Bob Wallace Avenue, Suite 107
Huntsville, AL 35805
Lawrence W. Spradley (205-536-8122)

This project will develop solution-adaptive techniques and a computer code for use in analyzing fatigue-crack propagation in aerospace structural components. A fracture analysis computational tool will be created using modern adaptive finite element techniques, extraction formulas, and crack-propagation theories. The code will be virtually a stand-alone module in that it will require no additional structural modeling other than a description of the material flaw. It will be developed as a post processor to existing finite-element program packages. The finite-element model of the unflawed structure will be prepared in the same manner as is currently done. Flaws can be introduced into these existing finite-element models and the fracture analysis performed in a manner virtually transparent to the user. With very little additional effort the stress analyst can then perform a fracture-mechanics analysis. Phase I will focus on solution-adaptive algorithm development and will utilize stress-intensity factor calculations for fatigue-life prediction. Phase II will include research and development into constitutive theories of fracture, accurate stress recovery procedures, adaptive refinement strategies, and development and delivery of a general three-dimensional code.

Potential Commercial Application: The computer code will be valuable to aerospace, mechanical and civil engineers in all disciplines for design of high-rise buildings, analysis of damaged buildings, structural fatigue analysis of commercial airplanes, and safety of automobiles, bridges, and highways.

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042 LeRC
90-1-04.01-8200 NAS3-26153
Real-Time Monitoring of Material Degradation of Fiber Composites
Structural Integrity Associates
3150 Almaden Expressway, Suite 226
San Jose, CA 95118
S. S.(Stanley) Tang (408-978-8200)

A novel approach to on-line monitoring of degradation of composite material will be investigated. This approach utilizes the dynamic response characteristic of the composite components and a pattern-recognition method. The dynamic responses of a perfect and a degraded component can be simulated through a finite-element analysis. The results can be used in a training-learning exercise through an expert system to classify the degradation status of other similar components. This approach will allow an efficient, qualitative assessment of the well-being of the component.

Potential Commercial Applications: This approach can provide an efficient means for the quality control and on-line monitoring of composite components in aircraft.

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043 LeRC
90-1-04.01-8900 NAS3-26151
Thermo-Chemical Structural Analysis of Carbon-Phenolics with Pore Pressure and Pyrolysis Effects
PDA Engineering
2975 Redhill Avenue
Costa Mesa, CA 92626
Tim Kuhlmann (714-540-8900)

Carbon-phenolic (c/ph) composites have been widely used in solid rocket motors despite the fact that their high-temperature, thermostructural behavior is not well understood. Many of the failure modes (e.g., wedge-out, ply-lift, delamination, pocketing) commonly seen in the c/ph components of fired SRM nozzles can only be explained as pore-pressure-induced phenomena that occur during pyrolysis. Yet, current thermostructural analysis methods are incapable of accurately predicting the high heating rate behavior of simple c/ph test specimens, let alone accurately characterizing the pore pressure and pyrolysis behavior of an actual motor nozzle. This project addresses the problem of accurately characterizing the thermostructural behavior of c/ph subjected to a high-temperature and heating-rate environment as typically found in a solid rocket motor. This will be accomplished by using a volume-based continuity model to couple the thermo-chemical to the thermostructural analysis. This unique approach models the pore-pressure development during pyrolysis more accurately than current analytical methods since it couples the pore-pressure level directly to the structural deformations.

Potential Commercial Applications: An accurate thermo-structural analysis method for carbon-phenolic materials would be extremely important to increasing the performance, reliability, and level of confidence in the design of large solid-rocket motors.

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044 LeRC
90-1-04.02-4888 NAS3-26237
Method for Producing Ultra-Pure Titanium Aluminide Wire for Arc-Spray Feed
Delta G Corporation
9960-A Glenoaks Boulevard
Sun Valley, CA 91352
Robert A. Holzl (818-767-4888)

Metal-matrix composites are being considered as exceptionally useful materials to replace very-high-performance, light-metal alloys and super-alloys for very high thrust-per-pound aircraft propulsion devices. There are many manufacturing difficulties with these materials, however. A major one is the consolidation of continuous fiber reinforcement with the matrix into a useful intermediate product such as tapes. One particularly attractive way of doing this is by the use of arc-spray transport of the intermetallic material. Such a process requires an uncontaminated-wire feed material. Manufacture of such a wire by conventional means is very difficult, if not impossible. This work aims to demonstrate the feasibility of making an ultra-high-purity, intermetallic wire material by chemical vapor deposition of titanium aluminide on a very small, high-purity, seed wire. This method not only provides a convenient way of making the wire without conventional drawing problems but also the prospect of eliminating the problem of interstitial contamination.

Potential Commercial Applications: A better method to make the tape intermediate for metal-matrix composite bodies would allow MMCs to replace a large percentage of high-performance light metal and super alloys for gas turbines and other applications.

***

045 LeRC
90-1-04.03-1980A NAS3-26137
Making $FeBe_5$ Fibers Using a Dual Plasma Deposition System
Materials & Electrochemical Research
7960 S Kolb Road
Tucson, AZ 85706
R. O. Loutfy (602-574-1980)

New fibers are needed to produce intermetallic composites for use in aero- and space-propulsion systems because existing fibers do not have adequate thermochemical stability in desirable structural materials such as iron aluminide. $FeBe_5$ has been predicted to have thermochemical stability in iron aluminide and would be a desirable reinforcement if it could be produced in a high-strength, fibrous form. A new dual plasma process has been developed that has the ability to deposit $FeBe_5$ and other difficult-to-deposit materials at high deposition rates. The dual plasma process will be utilized to develop the deposition of $FeBe_5$ into oxide fiber substrate producing fiber diameters up to 75u. The $FeBe_5$ fibers will be characterized for mechanical properties and compatibility in an iron aluminide matrix.

Potential Commercial Applications: Iron beryllide fibers, predicted to be thermochemically stable in iron aluminide, other intermetallics, and metals, could be applied in composites for a wide variety of aero-and space-propulsion systems and aerospace structures as well as tools, dies and general structures.

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046 LeRC
90-1-04.03-4888A NAS3-26138
High-Performance, Textile-Grade, Micro-Laminate Fibers
Delta G Corporation
9960-A Glenoaks Boulevard
Sun Valley, CA 91352
Robert A. Holzl (818-767-4888)

A technique has been devised to make high-operating-temperature, ceramic, micro-fibers by chemical vapor deposition of a silicon carbide ultra-structure on a filamental seed. Chemical vapor deposition for making fibers is old art, but the fibers produced were always macro-fibers, some of which have performed very well

because of the very high strength of the deposited material. The approach taken in this project makes use of CVD techniques to deposit a micro-laminated structure, wherein the laminates do not exceed 50 nm in thickness. Great toughness is expected from these fibers. Because of their small diameters they will be textile-grade fibers. Additionally, barrier coatings will be applied as the final laminate without interruption of the process.

Potential Commercial Applications: Successful completion of this project should provide improved, micro-fibers for light-weight, erosion, and oxidation-resistant metal-matrix and ceramic-matrix composites for aerospace vehicle and engine use.

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047 LeRC
90-1-04.03-8080 NAS3-26155
Coated Graphite Fibers for Highly Conductive Composites
Technical Research Associates, Inc.
410 Chipeta Way, Suite 222
Salt Lake City, UT 84108-1209
Joseph K. Weeks (801-582-8080)

Copper-graphite composites offer a unique combination of high thermal conductivity and high-temperature strength and modulus. They are particularly useful for thermal management in space power generation. However, because molten copper does not wet graphite, hot pressed copper/graphite composites are not thermally stable, developing pores and swelling when exposed to high-temperature environments. The purpose of this project is to develop a reliable and reproducible coating process for graphite fibers that would allow the fibers to be wet by molten copper. This not only will improve the thermal stability of the composite but also make it easier to produce complex forms and structures by means of the air-stable coating. The coating is compatible with other metals, such as aluminum, allowing use of the same coating to produce aluminum-graphite composites.

Potential Commercial Applications: The high conductivity of the composite may be useful as a heat sink for high-power integrated circuits. Other composites which would be developed in future research, such as aluminum-graphite, would be useful for aerospace structures.

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048 LeRC
90-1-04.03-8476 NAS3-26133
Innovative Laser Fiber-Testing Furnace
Penn Laboratories, Inc.
83 Mountain Ridge Road
Cartersville, GA 30120
Wayne Penn (404-974-8476)

The innovative fiber laser furnace offers the opportunity for new technology in the single-crystal fiber testing laboratory. Single-crystal fiber research involves the production of new single-crystal fibers with subsequent strength testing. Extensive testing requires heating the fiber to the operational temperatures of the fibers application. In this case, problems occur with the heating of a small mass that is surrounded by a massive testing machine. Typically, use of bulk-type resistance heaters requires large amounts of electric power to reach the testing temperatures. These heaters also heat up the fiber clamps and surrounding machine, increasing the difficulty of measurement. This project investigates a laser-heated furnace to facilitate the testing of aerospace fibers.

Potential Commercial Applications: This product would provide for the upgrading of fiber-testing machines to enhance measurement capabilities.

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049 MSFC
90-1-04.04-1980 NAS8-38889
Protective Refractory-Alloy Composite Coating Using Novel LTAVD Technique
Materials & Electrochemical Research
7960 S Kolb Road
Tucson, AZ 85706
Lori A. Leaskey (602-574-1980)

There is a critical need to eliminate the severe restrictions imposed on the use of many alloys in advanced propulsion systems due to hydrogen embrittlement and oxygen instability. The application of a stable coating that could protect the alloy from those environmental hazards would substantially improve the efficiency and performance of components in those systems. One proposal for accomplishing this is the application of a ZrO_2-TiC alloyed composite coating of a possibly graded composition. ZrO_2 has a thermal expansion coefficient approaching that of metals (reducing thermal stress), and the ZrO_2-TiC material has previously exhibited low wear at both low and high temperatures. This coating will be deposited using a novel coating approach in which the ceramic composite is used as the cathode in an electric arc discharge mode. The proposed technique deposits materials in an innovative manner at very high kinetic energies, resulting in excellent adhesion and a high deposition rate. In addition, this deposition of multicomponent refractory materials is achieved without introducing a significant amount of heat to the substrate.

Potential Commercial Applications: The successful application of low-temperature coating of multi-component refractory composites could be applicable for propulsion system components, aerospace components, engine components, cutting tools, and wear parts.

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050 MSFC
90-1-04.04-5200 NAS8-38917
Environment-Resistant Coatings for Ti-Alloys
Materials Technologies Corporation
57 Maryanne Drive
Monroe, CT 06468
Yogesh Mehrotra (203-261-5200)

The NiCoCrAlY composites are extensively used for oxidation protection of Ni-base superalloys. However, for higher temperature Ti-alloys, this overlay will react with

the substrate thus defeating the intended purpose of the coating. This project explores the development of a composite coating where an intermediate NiTi layer is interposed between the titanium alloy and the NiCoCrAlY overlay. The ductile NiTi layer can accommodate interfacial stresses generated due to the thermal expansion mismatch between the base material and the protective coating. In addition to NiTi being compatible with titanium, it is expected to be compatible with the NiCoCrAlY layer as well. The establishment of this composite coating approach will result in a rather quick and easy adaptation of the well-examined and applied NiCoCrAlY coating to titanium alloys, thus enhancing their capability for high-performance gas turbine applications.

Potential Commercial Applications: Applications would be in structural and gas-turbine engine applications where higher operating temperatures can result in significantly higher thermal efficiencies and where an improved environmental resistance can significantly improve the in-service life of the component.

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051 LeRC
90-1-04.05-2380 NAS3-26149
Enhanced Computational Structural Methods for Aerospace Applications
AI Ware Incorporated
11000 Cedar Avenue
Cleveland, OH 44106
Dejan J. Sobajic (216-421-2380)

Two methodologies for increasing the efficiency and effectiveness of computer analysis of aerospace structures will be addressed. The approach incorporates functional-link, neural-net technology for generalization of quantitative analysis results (so as to circumvent the need for extensive, time-consuming reanalysis) and episodal associative memory for capturing design experience to guide creation of subsequent designs developed by the firm. The functional-link net methodology is a neural-net technology that is particularly useful for learning functional relationships, providing accurate quantitative estimates in response to designs, and converging in on optimal designs. The episodal associative memory is a computer architecture for organizing and storing experimental knowledge that can be retrieved associatively in response to new tasks. This additional function can be effective in directing the creation and analysis of a new design.

Potential Commercial Applications: The resulting computer software systems will greatly enhance the power of all finite-element analysis tools and optimal design tools. This technology will find use in virtually all computer design aids offered commercially.

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052 LeRC
90-1-04.05-8166 NAS3-26152
A New Machine Architecture for Structural Analysis
Space Tech Corporation
125 Crestridge Drive
Ft. Collins, CO 80525
Michael Andrews (303-223-8166)

The project involves development of a fast, novel, scientific workstation for solving aeropropulsion system structures with cyclic symmetry exhibiting nonlinear response in high temperatures. An engineering study will map efficient algorithms onto new parallel architecture that is extensible across both the SIMD and MIMD design paradigm. A significant feature of the approach is the coupling of the same computational kernel to several processing elements so that true parallel computing without usual data-partitioning overhead occurs. A fully parallel, single instruction/clock crossbar ASIC is to be implemented for the dynamically reconfigurable architecture. This can now be achieved only through recent VLSI discoveries with ASIC devices. Because the computer hardware "glue logic" has shrunk, physical boards and backplanes have also reduced to make economic designs at 200 MHz clocks feasible.

Potential Commercial Applications: This fast architecture is attractive for several biomedical applications, including MRI, CATSCAN, PETSCAN, and ultrasound imaging, because the efficient parallel algorithms and data-streaming speeds reduce both computation time and hardware costs.

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053 LaRC
90-1-04.06-1477 NAS1-19264
Pressure Infiltration of Net-Shape Graphite Preforms for Metal-Matrix Composites
Applied Sciences, Inc.
P.O. Box 186
Yellow Springs, OH 45387
Max L. Lake (513-767-1477)

Much of the cost of advanced composites is due to fiber handling and consolidation. These "fiber placement" costs rise as the shape of the component becomes more complex and as the number of reinforced directions increases. This project will investigate a new method for producing three-dimensional, carbon-reinforced metal-matrix composites. All fiber-handling steps are eliminated through the use of a new preform material. This novel material is produced by in-situ creation of vapor-grown carbon fiber (VGCF) upon a molded carbon scaffold. VGCF has a unique morphology that may act as a mechanical fuse to improve composite toughness. Although produced from inexpensive hydrocarbon gases, VGCF's properties approach those of single crystal graphite, including a modulus of 87 MSI, strength of 1.0 MSI, and thermal conductivity of 1950 W/m K. Metal-matrix composites will be fabricated using a pressure infiltration technique developed by James Cornie, director of the Laboratory for Inorganic Composites at MIT.

Potential Commercial Applications: Applications include low-cost metal-matrix composites for high-performance structural and thermal management applications. Specific commercial components includes electronic heat sinks, packaging material, and space-based thermal radiators.

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054 LaRC
90-1-04.06-3200 NAS1-19254
Synergistic Prepregging Technologies
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Deborah P. Tuohy (617-890-3200)

High-performance, thermoplastic (TP) resins are notoriously difficult to melt-prepreg because of their high viscosities, and high-modulus fibers for advanced composites are difficult to handle and melt-prepreg. Two innovative prepregging technologies will be combined with advanced fiber/matrix materials to form prepregs that provide superior structural efficiency and excellent high-temperature performance. These synergistic technologies are high-shear prepregging (HSP) and maximal fiber spreading (MFS). HSP technology dramatically reduces TP resin viscosities by shear-thinning and readily accomplishes complete fiber impregnation. Current commercial prepregging technology yields prepregs with minimum fiber areal weights (FAW) of only 90 g/m^2. Foster-Miller's MFS technology will be able to achieve FAWs of 30 g/m^2. Combining these two technologies will result in ultrathin, high-performance thermoplastic prepreg, which will provide significant structural weight savings and enhanced performance in aerospace applications. This Phase I effort will demonstrate the synergistic prepregging technologies by designing and fabricating a small-scale demonstration MFS system that will be used in conjunction with HSP technology to produce high- quality Gr/LaRC-TPI prepreg with a FAW <35 g/m^2. This prepreg will be molded into laminates for SEM, tensile testing, and sampling to NASA.

Potential Commercial Applications: Ultrathin (1 mil thickness), high-performance TP prepreg can be used with automated fabrication methods to make aerostructure components for commercial applications such as high-speed civil transport, tubular members for space structures, and ultra-lightweight beam structures.

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055 LaRC
90-1-04.06-6000 NAS1-19257
Protective Coating for Carbon-Carbon Composites
Spire Corporation
Patriots Park
Bedford, MA 01730
Ward D. Halverson (617-275-6000)

Carbon-carbon (C-C) has an extremely high strength-to-weight ratio and would therefore be the material of choice for hot structures on hypersonic vehicles if its oxidation resistance could be improved. To achieve this objective, a coating system will be developed in which a very thin film of platinum serves as the final line of defense against oxidation. Platinum has a high melting temperature, excellent oxidation resistance, and is ductile enough to avoid cracking during thermal cycling. To ensure good adhesion, the platinum film will be formed on C-C by ion beam-assisted deposition (IBAD). IBAD will be used in Phase I to platinum coat two-dimensional C-C coupons; the coupons will be evaluated for oxidation resistance up to 2500°F during thermal cycling. Successful Phase I results will lead to fabrication and testing of C-C panels with platinum films forming part of an oxidation-resistant coating system. The platinum film will be one component of a system incorporating matrix oxidation inhibitors, ceramic surface coatings, and glassy crack sealers--resulting in multiple lines of defense against composite oxidation.

Potential Commercial Applications: Successful development of oxidation-resistant coatings for C-C composites would increase the lifetime of aerodynamically heated surfaces of high-performance aircraft and hypersonic vehicles, as well as turbine- and rocket-engine components. Additional applications include furnaces for drawing glass fibers and hot tooling in the steel industry.

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056 LaRC
90-1-04.06-9709 NAS1-19263
Remotely Deployable, Self-Rigidizing Composite Space Structures
United Applied Technologies, Inc.
P.O. Box 7207
Huntsville, AL 35807
Rodney Bradford (205-895-9709)

Major design and cost factors in space structures are deployment and dimensional stability. These are particularly important considerations for large space structure assemblies associated with the Space Station, space platforms, large deployable antennas, solar energy collectors, and many other applications. Innovative space structures that use lightweight non-metallic, high-strength, reversible and non-reversible polyimide composite materials will be evaluated to determine their feasibility for remote deployment and self-rigidization. The polyimides to be evaluated were developed for enhanced resistance to the space environment. The composite materials fabrication process will be refined; structural elements will be fabricated and tested individually and in a proof-of-concept deployable structure configuration. The results of this research will demonstrate the feasibility of deployable space structures with superior characteristics.

Potential Commercial Applications: This technology has commercial application in space platforms, large satellites, and satellite-servicing operations.

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057 LaRC
90-1-04.07-0236 NAS1-19286
Advanced Power Synthesis for Improved High-Temperature Light Alloys
Ultramet
12173 Montague Street
Pacoima, CA 91331
Brian E. Williams (818-899-0236)

This project will demonstrate the feasibility of a unique new method for producing dispersion-hardened alloys. Dispersed, stable, second-phase particles having a controlled morphology will be incorporated into matrices of aluminum and titanium alloys. This will be accomplished by coating each particle of the matrix powders with titanium diboride (TiB_2) by chemical vapor deposition (CVD), followed by milling/grinding to disperse the second phase into the particles. Successive coating/milling steps will guild up the desired volume fraction of dispersed second phase (=20 percent), followed by consolidation. Additionally, TiB_2 reinforcement particles will be coated with titanium and aluminum and then consolidated. The combination of CVD coating and mechanical alloying to provide an intimate mixture of a dispersed second phase will result in an innovative advance in metal-matrix composite processing. At the same time, it effectively eliminates problems of homogeneous mixing, distribution of second-phase particles, and contamination by impurities. This process for incorporating new strengthening and stiffening phases in light metal alloys and intermetallic materials can be directly scaled to production quantities. At the same time, properties of the dispersed phase (particle size, volume/weight fractions) will be controllable and repeatable over wide ranges.

Potential Commercial Applications: This process will also address current needs for advanced composite materials with low density, high specific strength and modulus, high damage tolerance, and, when exposed to long-term thermal cycling, resistance to micro-cracking.

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058 LaRC
90-1-04.07-1933 NAS1-19260
Novel Higher Temperature Aluminum Alloys by Rapid Consolidation of Glassy Structures
Ceracon, Inc.
1101 North Market Boulevard, Suite 9
Sacramento, CA 95834
Ramas V. Raman (916-928-1933)

NASA is interested in new aluminum alloys of non-equilibrium chemistries with the objective of increasing the upper-use temperature by 200F. Prior art has dealt with the use of rapid solidification to form fine-grained crystalline alloys based on Al-Fe-V-Si, Al-Fe-Ce, and Al-Fe-Mo-V. Although these alloys have shown promise in improving use temperature, significant further improvement could be made by controlled crystallization and consolidation of recently developed, high-crystallization-temperature glassy alloys (Tc=450C). However, conventional consolidation processes such as hot pressing and hot isostatic processing are not amenable to simultaneous requirements for full density, small grain size, and low cost. Recently, a quasi-isostatic, high-pressure consolidation process developed by the firm enables consolidation at short times (5-30 secs.) and at lower temperatures than hot isostatic processing, while achieving full density. Phase I will evaluate the feasibility of producing fully dense, ultra-fine-grained aluminum alloys by controlled crystallization of a glassy aluminum Al-Si-Fe-Y alloy that is thermally stable to high temperatures. Phase I is expected to show that the goal of attaining 200F increases in use temperature of aluminum alloy is feasible. The data generated in Phase I will enable Phase II to focus on upscaled fabrication of large billets and will involve evaluation of metal working to form sheets, forgings, and plates. Extensive mechanical testing will also be carried out in Phase II.

Potential Commercial Applications: None provided.

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059 MSFC
90-1-04.08-1933 NAS8-38890
Low-Flow, Arc-Head Vacuum Welding
Electric Propulsion Laboratory, Inc.
440 North Green Street
Tehachapi, CA 93561
Graeme Aston (805-822-1933)

On-orbit welding for either assembly or repair of future Space Stations and platforms will require novel approaches to the design of the arc-type welding heads, to ensure that this very successful form of metal joining can be applied in the vacuum of space. In particular, the clean welds accomplished using the tungsten inert-gas (TIG) and plasma welding approaches make these common and fairly well understood techniques highly desirable for space application. Although air contamination is not a problem in space, existing commercially available TIG and plasma welding heads require large inert-gas flow rates (approx. 1-10 liters/min.) for arc stability. This gas-consumption requirement is unacceptable for a practical space-based welding technique. A novel method of lowering this gas consumption will be developed by using a hollow cathode in place of a solid tungsten cathode electrode to reduce the inert-gas flow requirement to approx. 0.02 liters/min. for weld currents of hundreds of amperes.

Potential Commercial Applications: Low-flow, arc-head vacuum welding would have application in future NASA and commercial space-based fabrication. This vacuum-welding concept could also be a more versatile and attractive technique than certain ground-based, electron-beam production welding systems.

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060 MSFC
90-1-04.08-2200 NAS8-38908
GMA Welding in Space
General Digital Industries, Inc.
6705 Odyssey Drive
Huntsville, AL 35806
Timothy B. Morris (205-837-2200)

Construction and assembly of large structures will require use of various metal-joining processes. Welding is one of several methods under consideration for this

purpose. Gas metal arc (GMA) welding has advantages over other welding processes (i.e., laser, election-beam, and plasma arc welding) considered for use in space because GMA welding is more easily suited to manual and autonomous operation and requires less power to operate, and equipment costs are considerably less. This effort will empirically determine the feasibility of GMA welding in a vacuum and then project the influences of weightlessness, temperature, and remoteness on the feasibility of using this process in space. The successful development of the proposed GMA welding system will make it a candidate for assembly and maintenance of large structures in space.

Potential Commercial Applications: Applications include direct use by NASA contractors responsible for Space Station assembly and maintenance. Indirectly, this development will reveal methods for improving commercial weld processing on earth.

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061 MSFC
90-1-04.08-8877A NAS8-38918
Neural Networks for Welding Control
Mid-South Engineering, Inc.
2131 Belcourt Avenue
Nashville, TN 37212
Kristinn Andersen (615-383-8877)

This project is developing methods to use artificial neural networks for modeling and control of arc-welding processes. Artificial neural networks will be compared with more traditional models, such as those derived from the physics of heat conduction, and techniques for combining the use of both in modeling and control will be explored. Artificial neural networks are advantageous in that essentially no explicit model derivation of the process is necessary. Rather, neural networks are trained with real welding data from the process to be modeled, and they adapt themselves autonomously to "learn" or capture the general process characteristics. It has been shown that neural-network models are generally numerically more accurate and usually faster in execution than most of their traditional, physically based counterparts. Typical accuracy in predicting geometrical features of welds is on the order of 10 percent or better. Physically based models, on the other hand, provide intuitive insight into the processes, and they will be used here for guiding and checking the overall validity of the neural-network solutions.

Potential Commercial Applications: This project is likely to result in increased productivity and improved process quality of arc welding.

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062 LaRC
90-1-04.09-1911A NAS1-19274
Feature-Enhanced, Ultrasonic Flaw Detection and Micro-Structure Characterization Algorithms for NDE Systems
Information Systems Technology, Inc.
413 East 61st Street
Clarendon Hills, IL 60514
Martin J. Volk (708-887-1911)

In this project, some novel signal-processing techniques for feature-enhanced, ultrasonic NDE systems will be examined and implemented. The processing techniques have two objectives: to reduce the background noise in order to improve flaw visibility and sizing, and to obtain signal parameters that can be correlated to the microstructure for characterization. An interactive software package for an Apple Mac II platform, adaptable to the NDE ultrasonic system at NASA, will be developed and implemented. For enhanced ultrasonic flaw detection, a split-spectrum processing followed by averaging, median filtering, minimum detection, quadratic optimal detection, and generalized-order statistic filtering will be developed. Novel algorithms for microstructure imaging and characterization such as temporal smoothing, dispersive velocity estimation, correlation processing, homomorphic processing, power spectrum and moment estimation, and linear predictive coding will be developed and implemented.

Potential Commercial Applications: The system would allow cost-effective use of state-of-the-art, signal-processing algorithms for improved flaw detection and microstructure characterization in a portable, ultrasonic, non-destructive testing environment.

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063 LaRC
90-1-04.09-8120 NAS1-19262
Thermographic Stress Analysis and NDE via Focal Plane Array Detectors
Stress Photonics, Inc.
1504 Edgehill Drive
Madison, WI 53705
Neal F. Enke (608-238-8120)

This innovation will advance the state of the art and practical capabilities of thermographic stress analysis (TSA) and nondestructive evaluation (NDE) to investigate and predict the mechanical behaviors of models and real structures. A benchmarking method will be established to optimize stress resolution and speed of imaging. A new TSA/NDE system based on focal plane array detectors will be designed and analytically evaluated. The objectives are to quantify the net capability of any existing or proposed TSA/NDE instrument, estimate the expected improvement of the proposed system over current ones, and create the preliminary design of an instrument with high stress resolution and speed. The anticipated results of Phase I work will include a prototype benchmarking instrument that will aid in determining the feasibility of the new TSA/NDE instrument. The prototype of the new device will be made during Phase II, aiming for NASA applications in basic material studies (monolithics and composites; wide range of

temperatures), and quantitative, stress-based NDE and life prediction of machines and structures. The method will be capable of full-field, noncontacting analysis of objects loaded sinusoidally or self-excited, such as engines.

Potential Commercial Applications: The new TSA/NDE device will be commercialized by production and sale of standardized or customized hardware and software, and by contractual testing of materials, components, machines, and structures.

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064 GSFC
90-1-04.11-3200 NAS5-31404
Liquid Crystal Polymers for CTE-Matched PCBs
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Leslie Rubin (617-890-3200)

This project addresses the use of liquid-crystal polymer (LCP) materials and processes to fabricate laminated printed-circuit boards (PCB) with the in-plane coefficient of thermal expansion (CTE) matched to the ceramic-chip carriers (6 to 7 ppm/°C) and the out-of-plane CTE below 30 ppm/°C. This approach will solve the problem of thermal-fatigue-related failures of solder joints, enabling the implementation of surface-mount technology in space flight electronics. Also, this approach will enable the use of reliable multilayer circuits by minimizing thermally induced stresses on plated, through-hole vias. The result will be performance gains (weight and volume reductions over 50 percent below current designs), clock speed and memory-size increases, and reliability for extended (up to 20 year) missions. In Phase I, a unique film extrusion process, followed by novel post- processing techniques to tailor the CTE of the LCP circuit layers, will be used to demonstrate that innovative materials and processes can eliminate the problem of thermal fatigue in solder joints. In Phase II, techniques will be developed for fabricating multilayer boards with LCPs. The solder joint's performance and reliability advantages, as well as the commercial viability of these new materials over the current state of the art, will be demonstrated.

Potential Commercial Applications: Controlled CTE, multilayer PCBs will permit NASA's future space programs (such as the Advanced Tracking and Data Relay Satellite System) to use the increased speed, smaller size, lighter weight, and larger memory offered by current leadless ceramic-chip carriers and surface-mount technology.

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065 GSFC
90-1-04.11-8166 NAS5-31390
Automated NDE Scanner for Cracks
Space Tech Corporation
125 Crestridge Drive
Ft. Collins, CO 80525
Michael Andrews (303-223-8166)

This project capitalizes on three emerging technologies by integrating a flexible membrane (as a highly efficient transducer) impressive scanning and imaging algorithms found in medicine, and low-cost PC-based computers with a fast, digital signal processing (DSP) board. The eventual machine will be capable of supporting rapid testing of ferrous and non-ferrous materials while on the assembly line with little operator attention, thus reducing quality control costs directly at the factory as a type of "go, no go" detector. This will be made possible in large part by the rugged and flexible transducer harness, which will be impervious to a harsh manufacturing environment; the high quality of signal analysis afforded by tomography; and the currently low-cost computers.

Potential Commercial Applications: NDE of weldments, airframe integrity, mechanical-bearing analysis, bone-tissue diagnosis, dental surgery, and economical seismic exploration will benefit from a low-cost, expedient, ultrasonic NDE analyzer.

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066 KSC
90-1-04.11-9049 NAS10-11753
Conductive Paints Based on Soluble Conducting Polymers
Gumbs Associates, Inc.
11 Harts Lane
East Brunswick, NJ 08816
Ronald W. Gumbs (201-257-9049)

Recent unrelated work at the company has yielded a major breakthrough in conducting-polymer technology, with soluble, processible polymers with high solubility in organic solvents, and homogeneous, reproducible thin films with conductivities as high as 1,000 S/cm. The present work seeks to further enhance conductivities of these polymers, based on trends identified in the prior work, and also to prepare and evaluate paints by dispersing solutions of these elastomeric copolymers with conductive carbon black. These copolymers will have anticipated superior conductivity, solubility, and processibility. The work will also attempt to improve solubilizing, processing, and coating techniques. The design of the targeted new copolymers includes consideration of improved elastomericity for better cryogenic application and environmental stability via exclusion of reactive substituents. Besides the advantages of weight, processibility, one-component nature, and stability, the proposed paints will be more conductive than currently available paints based on non-conductive binders.

Potential Commercial Applications: Lightweight, processible, and stable conductive coatings can be used in EMI shielding, IR emissivity and radar-signature reduction, and electrochromic displays.

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067 ARC
90-1-04.12-5367 NAS2-13368
Use of Honeycomb Technology to Save Weight in Composite Flexible-Blanket Insulation
S. D. Miller & Associates
1422 West 259th Street
Harbor City, CA 90710
Stephen D. Miller (213-539-5367)

Space shuttle flights have demonstrated the value of flexible ceramic blankets such as Advanced Flexible Reusable Surface Insulation (AFRSI) for reentry thermal protection on areas exposed to moderate heating rates. Other ceramic blankets are being developed for future spacecraft such as the NASP, Shuttle-C, and Aeroassist Orbital Transfer Vehicles. Pitts and Kourtides (1989) describe a hybrid insulation, combining ceramic blankets and multilayer insulations (MLI), which could reduce blanket weight by 500 g./sq.m. The advantage is realized because MLIs are approximately 100 times less conductive than ceramic blankets. This project will investigate further improvements in MLIs made possible by substituting honeycomb separators for the scrim or crinkled Kapton currently used in MLIs. The flexible honeycomb layers, which may be produced from polymeric or ceramic materials, are expected to be more durable than the crinkled Kapton and significantly lighter than scrim. The additional weight saved through the use of honeycomb could exceed 700 g./sq.m. The work will include thermal-conductivity measurements of samples at temperatures of 300° to 1300°K and pressures of 0.01, 0.1, and 1.0 atmosphere pressure. The data will be incorporated in a computer model to predict benefits to NASA missions.

Potential Commercial Applications: High-temperature insulation developed for spacecraft thermal- protection systems will lead to insulations for commercial aircraft, ovens, and cryogenic systems, and to other industrial applications.

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068 JPL
90-1-04.13-2407 NAS7-1134
Six-Degree-of-Freedom, Active Vibration Damping for Space Applications
Intelligent Automation, Inc.
1370 Piccard Drive, Suite 210
Rockville, MD 20850
Leonard S. Haynes (301-990-2407)

This project deals with vibration damping in space applications. The company has spent two years investigating and then simulating control of a high-speed, high-precision, six-degree-of-freedom motion stage based on a six-legged, parallel-link manipulator. This system exploits six magnetostrictive actuators, one in series with each conventional leg actuator. This allows the conventional actuators to provide six-degree-of-freedom positioning, while the six magnetostrictive actuators (which elongate under the influence of a magnetic field) provide an additional six-degree-of-freedom, high-frequency vibration isolation. Magnetostrictive elements are extremely light and can exert large forces at high frequencies. The six-legged, parallel-link mechanism, called a Stewart platform, provides a means to convert this one-dimensional displacement into six-dimensional, high-frequency, high-precision motion. In space structures, the vibrational forces will include flexing and twisting, and we believe that six-axis countermotion is essential to implementing high-performance, active-vibrator isolation and damping. The system being investigated will meet this requirement.

Potential Commercial Applications: This system would apply to engine quieting, camera stabilization, precision microscopy, and six-axis machining.

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069 JSC
90-1-04.14-2733 NAS9-18454
Quick-Look Modal Testing of Flexible Structures
Garman Systems, Inc.
One Blue Ridge Court
Getzville, NY 14068-1192
Ephrahim Garcia (716-636-3058)

An innovative, modal-test analysis technique for successful ground testing of large, precision space structures will be investigated. Traditional approaches to modal testing are hampered by the overwhelming amount of data that must be acquired, stored, and analyzed for these large, flexible structures, which reflects directly on testing costs and time. The application of data-compression principles to modal analysis is proposed as a method of providing a cost-effective, quick look at the test data. This is accomplished by a combination of automated zooming in on the bandwidths of interest, and efficient manipulation of the compressed information for the eventual visualization of the modal data. The speed and accuracy of the proposed quick-look method will be compared with standard modal-testing algorithms such as ERA, ITD, and the poly-reference method.

Potential Commercial Applications: This method is potentially faster than existing research and commercial packages, and would be applicable to all areas of modal testing (auto industry, spacecraft, computer industry, etc.).

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070 JSC
90-1-04.14-5325A NAS9-18488
Multi-Inlet Tubular Joint Structures for Spacecraft Application
Textile Technologies, Inc.
2800 Turnpike Drive
Hatboro, PA 19040
Tammy S. Ebersole (215-443-5325)

The aerospace community needs integrally woven, composite-joint structures. Joining technology has not kept pace with the improvements made to current and projected spacecraft to accommodate the increasingly harsh environments that spacecraft encounter during flight. This effort will focus on the development of technology to integrally weave complex multi-inlet joint structures. Graphite fiber tows will be used to fabricate the woven-fiber preform, and the resulting composite system will be infiltrated with molten metal to form a

metal-matrix composite. Development of this type of joint will offer the improved mechanical properties of the integrally woven preform and the enhanced environmental stability of the metal matrix. The resulting joint technology will allow spacecraft manufacturers to use a whole new family of composite joint systems.

Potential Commercial Applications: New composite-joint technology will play a key role in space-structure assembly (both ground based and in space) and in next-generation supersonic aircraft as well. These joints may be applicable to many high-temperature applications, including future hypersonic transports such as NASP and HSCT.

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071 JSC
90-1-04.14-7351 NAS9-18481
Magnetic Energy Absorber for Docking-Impact Attenuation
CSA Engineering, Inc.
560 San Antonio Road, Suite 101
Palo Alto, CA 94306-4682
David A. Kienholz (415-494-7351)

Magnetic, eddy-current devices based on rare-earth magnets are very attractive as passive absorbers of impact energy for spacecraft. Their advantages include highly predictable behavior; all-metal construction; insensitivity to temperature; high force/velocity ratio in a light, compact package; and ruggedness, simplicity, reliability, and ease of force profiling. A single unit capable of dissipating the kinetic energy of a typical orbitor-station docking could weigh less than 20 kg. A long stroke (order of 1 M) is practical and could be used to keep the peak impact force quite small. This effort will investigate the feasibility of a magnetic energy absorber as a docking-impact attenuator for Space Station Freedom. A dynamically scaled demonstrator device will be designed, fabricated, and tested in Phase I. Correlation of analytical design predictions and test results will be used to evaluate scalability of the design to the required size.

Potential Commercial Applications: Magnetic energy absorbers (dashpots) could be used in current applications that require a viscous damper to function reliably in a hostile environment or over a wide temperature range. Examples are seismic pipe snubbers in nuclear plants or tuned-mass vibration dampers for such low-frequency structures as aircraft and spacecraft.

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072 LeRC
90-1-04.15-0046 NAS3-25922
Epitaxial Growth of Semiconductors On High-T_c Superconductor Crystals
Superconix, Inc.
261 East 5th Street
St Paul, MN 55101
Cornell Chun (612-222-0046)

This project investigates the epitaxial growth of semiconductors (Si and GaAs) on single-crystal, high-temperature superconductors. These materials will lead to the monolithic integration of high-temperature superconducting devices and electronic/optoelectronic semiconductor devices. Epitaxial-semiconductor and high-T_c-superconductor materials will also lead to the invention of new devices involving the interplay of the as-yet-unknown superconducting mechanism and semiconductor physics. The development will involve: devising a method for substrate preparation; determining the substrate surface behavior in ultrahigh-vacuum at temperatures up to the film-growth temperatures; determining the optimum parameters for growth of each semiconductor; and characterizing the semiconductor and high-T_c-superconductor materials to determine structural, electrical, magnetic, and optical properties. Phase II will study the use of epitaxial semiconductor and high-T_c-superconductor materials for monolithic integrated circuit sensors, superconducting mixers for millimeter and far-infrared receivers, and semiconductor circuits for high-speed, on-chip signal processing.

Potential Commercial Applications: Applications could occur in millimeter, far-infrared receivers with wide bandwidth and low noise, focal-plane array receivers with on-chip signal processing and monolithic integration of high-speed superconducting electronics, and semiconducting electronics and optoelectronics.

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073 LeRC
90-1-04.15-6700 NAS3-25938
Large-Area, High-Temperature Superconducting Thin Films
Conductus, Inc.
969 West Maude Avenue
Sunnyvale, CA 94086
Nathan Newman (408-737-6700)

The high-temperature superconducting films now deposited in situ are large enough for research purposes and for production of a limited number of devices. But most practical devices and circuits will require high-quality films on large substrates. This project will develop a process for depositing high-quality films of $YBa_2Cu_3O_{7-\delta}$, with uniform thickness and uniform electrical properties, in technologically useful sizes--that is, on substrates 2 to 4 inches in diameter. Tools for measuring the properties of the large films locally, as well as in their entirety, will also be developed. The availability of large films and the tools for characterizing them will accelerate the commercialization of high-temperature electronics.

Potential Commercial Applications: Applications of high-temperature superconductors that require large areas of superconducting film patterned to provide the desired circuit characteristics include delay lines and chip-to-chip interconnects.

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074 LeRC
90-1-04.15-7646A NAS3-25926
Buffer Layers On Low-Loss Substrates for High-Temperature Superconducting Thin Films
Superconductor Technologies, Inc.
460 Ward Drive, Suite F
Santa Barbara, CA 93111-2310
Mcdonald Robinson (805-683-7646)

The objective of this project is to develop epitaxial buffer layers grown by chemical vapor deposition (CVD) that will provide both a diffusion-reaction barrier and a transition in crystal structure and lattice parameter between a low-loss, single-crystal substrate and an epitaxial, single-crystal, high-temperature superconducting film. Phase I will establish proof of concept via homoepitaxy. For example, MgO films will be grown on single-crystal MgO substrates, and $LaA10_3$ films will be grown on single-crystal $LaA10_3$ substrates. The films will be evaluated for crystal quality, surface smoothness, and uniformity, and process conditions will be adjusted to optimize film properties. In Phase II the process will be extended to heteroepitaxy, with the goal of providing epitaxial buffer layers for superconducting films on substrates, such as single-crystal $A1_2O_3$ (sapphire), that are highly desirable for microwave applications.

Potential Commercial Applications: A process that can successfully create epitaxial buffer layers on sapphire will aid in the manufacture of superconducting films and devices for microwave applications.

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075 LeRC
90-1-04.15-8623 NAS3-25927
Field Emission Enhancement and Confinement from Superconductive Surfaces
Tetra Corporation
4905 Hawkins N.E.
Albuquerque, NM 87109
Juan M. Elizondo (505-345-8623)

This project studies the feasibility of using a superconductive surface as the source of electrons for electron-beam diode applications. Ceramic-based materials such as $YBa_2Cu_3O_{6+x}$ will be tested. The material will be deposited as a coating on a metal electrode, and tested in solid form. This work will correlate the field-emission characteristics of the superconductive surface with the field-emission formulations of Fowler-Nordheim and Richardson-Dushman. The feasibility of using superconductive materials as electron sources for beam diodes will be determined by demonstrating coating integrity and superconductive-material electron emission under DC and high-voltage pulsed regimes. If this concept is feasible, current densities of more than 100 A/cm^2 will be demonstrated during the Phase I program.

Potential Commercial Applications: Anticipated benefits include: a high-current-density-electron-beam source for FEL, a modulated-electron diode with the emission surface turned on and off by a modulating magnetic field, accelerator resonant cavities with controlled or no field emission, and microwave oscillators in which the oscillating magnetic field controls the electron emission source.

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076 JPL
90-1-04.15-9023A NAS7-1132
High-J_c, High- Strength HTS Wire Using Newly Discovered Processess and Materials
HITC Superconco, Inc.
140 Bordentown Road
Tullytown, PA 19007
Roland Loh (215-943-9023)

The company has developed a concept to produce functional superconducting wire using the heretofore unsuccessful "powder-in-tube" process, dynamic compaction of the melt-process phase of SHS material generation, and high-pressure operation of the resulting aligned crystalline structure. The pre-reaction SHS powders will be placed in a silver tube. These powders will then be ignited using normal SHS mixtures and processes. As the flame progresses down the tube, creating a melt-phase liquid, the tube will be swaged down to compact the melt dynamically. This will force the crystals to lie down along their long axes in the tube. Upon cooling, the silver tube will contract a greater amount than the ceramic superconductor, putting the ceramic under pressure to improve the T_c and J_c. The company will use its BISCCO-Pb powder, which has a Tc onset of 117K.

Potential Commercial Applications: Applications would be in high-power magnets, antennas, power and data conductors, and sensors.

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077 LaRC
90-1-04.15-9450 NAS1-19259
High-T_c Superconducting Composites for Interconnects to Cryogenic Equipment
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Stuart F. Cogan (617-769-9450)

A vacuum-deposition process that promotes crystallographic orientation and high critical currents in $YBa_2Cu_3O_{7-x}$ films deposited on ceramic substrates will be developed as a means of fabricating flexible electrical interconnects to cryogenic equipment in the space environment. The interconnects will comprise a thin film of high-J_c $YBa_2Cu_3O_{7-x}$, deposited onto flexible ceramic tapes and filaments, a buffer layer, a vacuum- deposited oxide overlayer, and a low out-gassing, polymer encapsulant. Methods for reducing both conductive- and radiant- heat transfer are incorporated into the design. The interconnects would have significantly lower thermal conductivity, no I^2R losses (for DC applications), and would be of equivalent or lower weight than con-ventional metal interconnects. The low thermal conductivity will minimize cryogen (primary liquid-helium) loss and significantly increase the mission-life of sensors and other equipment requiring cryogenic cooling. The principal technical objective of the Phase I program is to demonstrate the deposition of high-J_c $YBa_2Cu_3O_{7-x}$ (J_c-

10^6 A/cm^2 at 77 K) on flexible tapes and filaments with an I_c of 20 A at 77 K.

Potential Commercial Applications: Spaceborne applications include optical sensors and cryogenic equipment (e.g., superconducting magnets) in scientific and military satellites with long mission life requirements. Applications also extend to interconnects between cryogenically cooled electronic packages in which I^2R heating and thermal conduction must be minimized.

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078 JSC
90-1-04.16-3200 NAS9-18453
Recovery of Oxygen From Lunar Soils in a Plasma Reactor
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Harris Gold (617-890-3200)

The specific focus of this project is a plasma process for the recovery of oxygen at high yield from minimally beneficiated lunar soils. In the process, the soil is dissociated into its elements in a plasma arc, and the oxygen is recovered by quenching the product mix. The objective of the Phase I program is to determine the feasibility of oxygen recovery from lunar soils in a plasma reactor without the addition of chemicals. Theoretical and experimental studies are planned. In the theoretical part of the program, estimates will be made of the temperature needed to ensure that most of the ore is dissociated into atoms, and the heat-transfer rate required to quench the reaction of cooling the product stream. These results will then provide the basis for evaluating the findings of the experimental tests to be conducted in a laboratory-scale plasma reactor. The cost of a full-scale facility will be estimated.

Potential Commercial Applications: This process can be adapted to develop an extremely clean and efficient technique for handling terrestrial waste. The process has the potential of breaking down and separating the most objectionable compounds in terrestrial waste.

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079 JSC
90-1-04.16-3260 NAS9-18450
Novel Approach to the Electrolysis of Oxides
EMEC Consultants
R.D. 3, Roundtop Road
Export, PA 15632
Rudolf Keller (412-325-3260)

Electrolysis of lunar oxides dissolved in a molten electrolyte is a promising approach to producing oxygen on the moon for propulsion and sustaining human life. Molten fluorides have been considered to be electrolytes in the past, because of their relatively low melting point and their high specific electrical conductivity. A properly selected all-oxide electrolyte may have similar beneficial properties and additional advantages in critical areas of the electrochemical process. This project thus involves the study of oxide melts and their application to the electrolysis of oxide mixtures as they occur in readily available lunar resources.

Potential Commercial Applications: The results of the project would be directly pertinent to the development of advanced terrestrial electrolytic pro-cesses, e.g., to produce aluminum metal with greater energy efficiency and without the emission of carbon dioxide.

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05: Teleoperators and Robotics

080 LaRC
90-1-05.01-0970 NAS1-19277
Human-Machine Interaction in Human-Assisted Robotic Systems
Netrologic, Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
James R. Johnson (513-253-1558)

This project introduces a new class of robot manipulators called extenders. Extenders are worn by humans and increase human mechanical ability while the human's intellect serves as the central intelligent control system for manipulating the extender. The human body, in physical contact with the extender, exchanges power and information signals with it. This project's objective is to develop ground rules for the control of robotic systems worn by humans through the design, construction, and control of a simple experimental extender. This knowledge will be the basis for the design and construction of a multi-degree-of-freedom extender in Phase II.

Potential Commercial Applications: The technique is applicable in areas in which human power needs to be exaggerated while retaining precise operator control, such as cargo handling or construction. A sample application might be a human-power amplified forklift.

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081 GSFC
90-1-05.02-0649 NAS5-31405
Analysis of the Human Musculoskeletal System for Teleoperator System Design
R. J. Williams & Associates
631 Harriet Avenue
Shoreview, MN 55126
Robert J. Williams (612-483-0649)

Teleoperators are key components of future space exploration missions. As the use of the teleoperators and the length of time people operate them increases, it has become necessary to evaluate the physiological and ergonomic parameters of the system. This project addresses this need by modeling the human musculoskeletal (m-s) system. The motion of the limbs, as well as the muscle and joint reaction forces required to produce the teleoperator motion and to overcome its feedback forces, are included. The model will be used to establish and to verify representations for physiological performance degradation due to pain and exhaustion

and to suggest optimal positions to extend the operator's performance. Phase I of this project will be concerned with the development of a general modeling procedure for the human m-s system and will assess its application in the evaluation of human performance of teleoperators.

Potential Commercial Applications: This model would provide teleoperators with better and lower cost ergonomic design, more effective designs of the work place for manual labor jobs, improved artificial joint designs.

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082 LaRC
90-1-05.03-0540A NAS1-19282
An Integrated Micro-Gyroscope
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Timothy J. Hawkey (617-661-0540)

Micro-electronic fabrication technologies have recently been applied to produce such novel micro-mechanical devices as motors, sensors, and actuators. Their small size and their easy integration with micro-electronics invite innovative research, but, thus far, few useful application concepts have been developed. One device with widespread application would be an electrically suspended micro-gyroscope. The motor, sensor, suspension, control, and interface electronics could be packaged on a single chip. The devices could be produced in large quantities at a low cost with widespread use in integrated navigation and control systems for end effectors, vehicles, or projectiles. A micro-gyroscope might also allow the development of very small autonomous airplanes, ground vehicles, or satellites for terrestrial, planetary, or space exploration. The first phase of this project will involve development of micro-machine design and analysis tools, their use to investigate possible gyroscope configurations, and the establishment of a baseline design for the mechanics, sensors, actuators, and electronics. A Phase II effort will include detailed design, fabrication, and testing of a prototype micro-gyroscope.

Potential Commercial Applications: An integrated micro-gyroscope would have commercial and governmental uses in a number of guidance and control applications. The advancement of micro-fabrication technology would also assist the development of other useful micro-devices.

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083 GSFC
90-1-05.03-0661 NAS5-31391
A Gravity Compensation System for Simulation of On-Orbit Telerobotic Operations
Honeybee Robotics
204 Elizabeth Street
New York, NY 10012
Steven J. Glapa (212-966-0661)

The goal of this project is a three-dimensional, electromechanical gravity compensation system for the purpose of duplicating on-orbit telerobotic operations. The project objective is to develop this concept to the point that the system parameters will allow, as a baseline, a full-scale flight version of the Space Station Flight Telerobotic Servicer to be manipulated with robust gravity compensation in a typical high-bay facility. Additional objectives include determining the range of the system's operational envelope in order to determine the parameters of the control and sensing systems and to validate system design aspects through breadboard hardware planning, design, fabrication, and testing. The results of this effort will be Level 1 concept and developmental design drawings (per DoD Directive 1000B) of the system. This will provide NASA with an innovative, low-cost method to approximate more closely on-orbit telerobotic activities that are not well duplicated in a traditional neutral buoyancy environment.

Potential Commercial Applications: The low-cost telerobotic simulator system will facilitate the development and implementation of satellite servicing operations, which, in turn, is expected to reduce satellite unit cost and thus improve the competitive posture of American satellite manufacturers.

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084 GSFC
90-1-05.03-2491 NAS5-31406
A Method for Improving the Dynamic Performance of Telerobotics Systems
Convolve, Inc.
132 Nassau Street, Suite 619
New York, NY 10038
Neil Singer (212-233-2492)

The objective of this project is to develop an approach that commands telerobots to move with greatly increased dynamic performance. This performance increase will be achieved by eliminating the excitation of oscillations in the machine. Settling time, therefore, will be significantly reduced. The feasibility of a new technique called impulse shaping will be investigated. A rudimentary version of this new technique has been demonstrated on simple research systems (both in software and hardware). The objective of this work is to formulate this technique for more complex machines. The results that have been obtained to date indicate that this technique, if pursued, could significantly improve the task-performing capabilities of telerobots and of other machines. This innovative extension of the impulse-shaping technique would result in a new technology available for machine control.

Potential Commercial Applications: Sample applications include: the shuttle Remote Manipulator System, equipment for payload experiments and satellites, the Space Station, the Mars Rover, the Space Shuttle Digital Auto Pilot, computer disk drives, silicon wafer steppers, wire-bonding machines, construction cranes, optical systems (i.e., etching machines), chemical processes, assembly equipment, NC machine tools, robotics, automobile active suspensions.

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085 GSFC
90-1-05.03-8500A NAS5-31396
Real-Time Object and Robot End-Effector Tracking System
KMS Fusion, Inc.
P.O. Box 1567
Ann Arbor, MI 48106-1567
Paul G. Gottschalk (313-769-8500)

Real-time, three-dimensional object tracking is the key to successfully completing robotic end-effector docking tasks in uncertain and changeable environments. Since reliable systems for tracking three-dimensional objects under realistic conditions do not yet exist, this project proposes to design a real-time object and robotic end-effector tracking system (RORETS). RORETS is centered on a recently discovered approach to estimate the position and orientation (pose) of arbitrarily shaped, partially visible three-dimensional objects in a single, cluttered, noisy image. To attain real-time performance, the firm has reformulated the theory behind the pose estimator and adapted a new representation of three-dimensional objects that allows ready prediction of the appearance of edge contours from any viewpoint. with appropriate hardware these innovations, coupled with a real-time implementation of a Kalman filter for estimating an objects' motion parameters, will allow RORETS to achieve real-time tracking performance.

Potential Commercial Applications: RORETS will provide the capability to track arbitrarily shaped, partially visible three-dimensional objects under realistic, noisy, and cluttered images, permitting robots to undertake tasks that were previously impossible. Applications include use of robots in industry, undersea operations, and construction.

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086 KSC
90-1-05.04-7828 NAS10-11754
Sensor-Based Whole-Arm Obstacle Avoidance for Redundant Robot Arm Manipulators
Merritt Systems, Inc.
2120 Leeward Lane
Merritt Island, FL 32953
Edward Cheung (407-268-4785)

This project addresses an experimental system for investigating issues in sensor-based obstacle avoidance for redundant, degree-of-freedom robot arm manipulators. The experimental system consists of a planar, three degree-of-freedom, redundant, robot arm manipulator. The perimeter of the robot arm is covered by a linear array of proximity sensors. The assembled computer system will allow the incorporation of robotic-motion planning algorithms to guide the robot arm around its environment without colliding into obstacles.

Potential Commercial Applications: Applications include the on-orbit or earth-bound processing of satellite payloads and the use of robot arms in hazardous or hostile environments such as underground mining, undersea exploration, or in factory workcells. Other applications include: industrial robots, aids for the blind, special-purpose tools, and prototype robots in universities and research labs.

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087 JSC
90-1-05.04-9570A NAS9-18474
Robot Fault-Tolerant Feedback System
Robotics Research Corporation
P.O. Box 206
Amelia, OH 45102-0206
Paul H. Eismann (513-831-9570)

Robotic systems capable of safe, reliable performance for long periods of time must be able to detect feedback transducer faults and to continue to operate without damage to payloads and objects in the workspace. This project aims to develop a method capable of quickly detecting errors in the torque, velocity, and position feedback and of providing a means to continue operation with some degradation of performance through the use of the unaffected feedback transducers. Through the differentiation and the integration of the feedback signals and the use of the motor current and BEMF voltage, close approximations of the actual feedback signals can be generated. Such a system would significantly improve the safety and reliability of the robotic system as well as reduce the need for redundancy, which complicates the mechanical design and increases the wiring harness size.

Potential Commercial Applications: The benefits of this project could be in the safety and reliability of industrial robots, application of robots in areas considered to be dangerous, troubleshooting of robotic systems, and in allowing people to work near manipulators.

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088 JSC
90-1-05.05-2806 NAS9-18462
Neural Networks to Monitor Space Station Distributed System
ALS Company
3210A Wheaton Way
Elicott City, MD 21043
Michael L. Phillips (301-963-4269)

Neural networks will be applied to monitor distributed systems on Space Station, with the eventual goal of developing hybrid neural network, expert systems, and conventional software systems to monitor and to control complicated systems. The Phase I effort will concentrate on using a network to monitor one distributed system and to differentiate between normal and abnormal operating conditions, and on analyzing the trained network to derive its strategies. The Central Thermal Bus will be simulated, and the resulting model will provide simulated sensor data for network training and testing. Normal operating conditions will be simulated, as well as specific system failures. Several networks will be trained using various transforms of sensor input, and the best network will be selected for analysis. Direct observation and calculation of the response of each node in the network to various input patterns will be used to derive network strategies. The successful techniques for monitoring complicated systems can be

extended to become distributed systems in space with human-like intelligence. Further applications in process control and military systems are expected.

Potential Commercial Applications: A system composed of neural networks, expert systems, and conventional software will be capable of human-like performance in monitoring and controlling complex systems.

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089 JSC
90-1-05.05-3474 NAS9-18479
A Hybrid Neural Network and Expert System Environment
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, with the ANNs providing soft constraints and expert systems, hard constraints. Specifically, ANNs perform nonlinear functions, pattern recognition, fault tolerance, and parallel processing; expert systems involve language processing, formal logic, and rule interpretation. The hybrid combination of ANNs and expert systems will facilitate the automation of various Space Station applications while providing unsupervised adaptability and real-time functionality. This project will identify and develop baseline architecture and requirements specification for the integration of neural networks and of expert systems to form a hybrid software environment. Additionally, strategies for the implementation of intelligent systems within the hybrid environment will be investigated for Space Station control and sensor monitoring applications.

Potential Commercial Applications: The application of hybrid neural-network and expert-system software environments will be designed by aerospace prime and subcontractors and government and university research laboratories.

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090 JSC
90-1-05.05-3635 NAS9-18487
MetaAgents: A Framework for Intelligent Distributed Systems
Symbiotics, Inc.
875 Main Street
Cambridge, MA 02139
Bruce H. Cottman (617-876-3635)

An intelligent distributed system presents significant integration and concurrency control problems. However, the tools that are currently available for distributed systems development in the areas of heterogeneous system integration and multiple process control are inadequate. An application that requires multiple process coordination and control requires intractably complex management of paired process sessions using these methods. This project focuses on the development of a framework that provides both high-level representation and alternative distributed control models by which fault-tolerant intelligent systems can access information and resources in a distributed heterogeneous environment. The basis of the framework interface will be an explicit, object-oriented representation of both the data types and operations of the distributed system models, services, and resources. This key innovation is required for highly adaptive, intelligent information systems as the distributed environment can be represented in terms of explicit, changeable descriptions. Additional key components of this framework are in the area of distributed control models: reduction of resource contention through group-based replicated services; distributed, reliable, group-based reconfiguration, and resource allocation mechanisms; and uniform interface across heterogeneous environments.

Potential Commercial Applications: Market segments that require intelligent distributed heterogeneous systems include operations support, command and control, and concurrent engineering information systems.

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091 JSC
90-1-05.05-9090 NAS9-18458
Diagnostic Control by Means of Model-Based Reasoning
Synetics Corporation
540 Edgewater Drive
Wakefield, MA 01880
Ranjeet J. Uttamsingh (313-737-5505)

Intelligent control systems are required for enhanced process control, automated diagnosis and repair functions. The goal is to increase Space Station reliability and automation for long duration missions through use of model-based reasoning techniques (MBR) as the basis for intelligent control systems. MBR has significant advantages over rule-based approaches: application development requires no a priori knowledge about failure modes; the initially deployed system will be capable of handling a much wider range of malfunctions; no knowledge engineering of human experts is required; the software development and maintenance time and efforts are less; application validation is much more thorough; and MBR modules may be easily reused for other applications. The objectives of Phase I are to demonstrate these capabilities by proof-of-concept software evaluations and to design the Phase II pilot application. A proven MBR tool developed out of research at the MIT AI Laboratory will be used as the basis of the intelligent control proof-of-concept system.

Potential Commercial Applications: Applications include self-monitoring and self-maintaining systems for aircraft, large computer systems, nuclear and other process plants, and other complex systems.

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092 JPL
90-1-05.06-0815O NAS7-1123
A Close-Up Fiber-Optic Remote-Viewing System for Robotic and Teleoperated Systems
Engineering Design & Systems
2012 South 314th Street, Suite 334
Federal Way, WA 98003
Dan L. Swannack (206-874-0815)

Physical access within confined spaces in spacecraft limits the ability of teleoperated manipulators/robots operators to observe work activities. Viewing is often obstructed at the end-effector work envelope due to the relative inflexibility of positioning closed-circuit television (CCTV) cameras and lighting on the robot. The Phase I project will assess the feasibility of and develop a preliminary design for a remotely operated, interchangeable fiberoptic viewing system that can be incorporated into a manipulator's end effector for use with end-of-arm tooling or for conducting remote inspection of internal structures. The system would employ an innovatively designed, remotely engageable connector that would be attached to the manipulator's end effector. Manipulator-mounted CCTV cameras and lights would connect via coherent fiberoptic cables to the remote connector. A mating connector, fiberoptic cables, and a miniature lens system would be incorporated into task-specific, end-of-arm tooling for unobstructed, close-in operator viewing of a work-task tool used with the manipulator. This concept allows interchangeable, remote tools to have self-contained remote viewing strategically integrated for optimal work efficiency and enhanced operator viewing.

Potential Commercial Applications: Applications would include deployment on underwater robotic vehicles, on military remote systems, on space platform manipulators, and on nuclear facility remote or robotic systems.

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093 JPL
90-1-05.06-2567 NAS7-1116
Intelligent Robot-Sensor Operations Planning Systems
Cybernet Systems Corporation
1919 Green Road, Suite B 101
Ann Arbor, MI 48105
Charles J. Jacobus (313-668-2567)

A telerobot-sensor planning system will be developed by combining mature vision-based guidance technology, standardized robotic platform interfaces, and an interactive robot planning system integrated into a graphical robotic visualization system. To support advanced robotic servicing operated from the ground (through time delays and bandwidth limitations), this technology will accommodate rapid servicer re-planning and mission modification due to the variability of on-orbit tasks. An improved sensor-robot programming environment will significantly extend the current ground-based technology in robots. The approach begins with incorporating CAD-based computer vision into a standardized robotic command and control structure (e.g., NASREM-like). Then standardized simulation modules with equivalent function to the standardized robotic and sensor processing subsystems will be implemented and used (in Phase II) by an AI planning environment (and connect to a conventional graphics system). This effort is expected to integrate with other supervised telerobotic server testbed development work at JPL (especially since the first task elements would demonstrate geometrical model-driven vision components on a VME compatible platform, driving standard robots like JPL's PUMAs).

Potential Commercial Applications: This development could facilitate a more dynamic use of robots in space, as wll as material handling, hazardous materials, and manufacturing applications.

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094 GSFC
90-1-05.07-0540A NAS5-31397
Magnetic Bearings to Eliminate Stiction and Reduce Vibrations in Reaction/Momentum Wheels
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Vijay Gondhalekar (617-661-0540)

This project addresses means to improve the operational performance and lifetime of existing reaction and momentum wheel assemblies on spacecraft. Instrumentation carried on spacecraft is becoming ever more sensitive and intolerant to vibrations caused by mass unbalance on reaction/momentum wheels. Resonant structural modes of the spacecraft can cause unexpected amplification of the vibrations leading to serious degradation in instrument performance. Stiction in the ball bearings of reaction wheels is an even more serious problem on extended missions. Stiction in the bearings has been serious enough to completely disable some of the GPS satellites. Use of magnetic bearings eliminates stiction and allows active control in order to minimize forces generated by the mass unbalance. Both vibration and stiction issues are addressed and a Phase I program is outlined for designing magnetic bearings and a controller to eliminate stiction and to minimize vibrations in reaction/momentum wheels. Phase II will be targeted for prototype development and eventually flight testing.

Potential Commercial Applications: Because methods for eliminating stiction and minimizing vibrations are applicable to all rotating machines, space-based or otherwise, this project will benefit a large spectrum of applications.

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095 JSC
90-1-05.08-0559A NAS9-18457
Extended Tactile Sensing for Dextrous Robotic Hands
Sarcos Research Corporation
261 East 300 South, Suite 150
Salt Lake City, UT 84111
Ian D. McCammon (801-581-6499)

A number of dextrous robotic hands have been developed for manipulation research and serve as precursors to devices planned for unstructured orbital environments. Typically these hands incorporate position and torque sensing at the joints but lack any cutaneous sense of touch. Since localized contact

information is essential for precise manipulations, researchers have investigated a variety of tactile sensing technologies, but no systems have emerged that embody the geometry, reliability, or sensory coverage required for a fully comprehensive sense of touch. The target of this project is a comprehensive, reliable sense of touch for dextrous hands. It will focus on developing a complete and robust system rather than simply devising a transducer array. Phase I will deliver a detailed design to NASA that will serve as a blueprint for Phase II construction of the system. Although the system will initially be designed for the Utah/MIT Dextrous Hand, it can be adapted to other hands in later phases.

Potential Commercial Applications: A full tactile sensing system would be a significant contribution to machine manipulation technology. Long-term applications include extended tactile sensing for complex robotic systems, such as those found in space, underwater, and hazardous terrestrial environments.

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096 JSC
90-1-05.08-2075 NAS9-18452
An Exoskeleton Arm Master for Robot Control
Exos, Inc.
8 Blanchard Road
Burlington, MA 01803
Beth Marcus (617-229-2075)

In this project, a master will be developed that consists of a 20-degree-of-freedom hand, a 2-degree-of-freedom wrist, and a 5-degree-of-freedom arm. This device will allow a human to control a dexterous robot in a master-slave or teach-playback mode to assist in developing autonomous robotic manipulation strategies. The work will integrate two existing products, the Dexterous Hand Master (DHM) and the GripMaster (GM) with an arm exoskeleton to be developed during this project. The arm exoskeleton will incorporate sensing and mechanical elements similar to that used in the DHM and GM. Existing DHM and GM electronics and software will be modified to accommodate the complete system. In NASA applications, the resulting system will provide a natural method for a crewperson in zero-G to control a multi-degree-of-freedom dexterous robot with minimal restraints. The technology will also be applicable to medial measurement problems including diagnosis and treatment of injuries from repetitive motions and sports. A reduced degree-of-freedom version will also be used in determining the sources of cumulative trauma disorders in workers and in designing tasks and tools to prevent these injuries in the future.

Potential Commercial Applications: The proposed innovation has direct applications in control of dexterous robots for space, military, and industrial environments. In addition, the technology will provide spin-off products in medial measurement and rehabilitation.

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097 JSC
90-1-05.08-7730 NAS9-18476
Design of an Integrated Arm/Wrist/Hand System for Whole-Arm Manipulation
Barrett Technology, Inc.
545 Concord Avenue
Cambridge, MA 02138
William T. Townsend (617-868-7730)

This project will design a complete, integrated robotic arm/wrist/hand system. The components of this design will be properly matched to maximize the overall system performance. The integrated design will be consistent with the durability, low-bulk, and high-performance requirements of whole-arm manipulation (WAM) by adapting newly invented mechanical-transmission technologies for whole-arm manipulation. The resulting integrated design will feature a slightly modified version of the WAM arm, a three-degree-of-freedom wrist with a cabled differential, and a simple, lightweight hand. As part of the Phase II project, a lightweight prototype will be built and integrated with a WAM arm and wrist for testing and for performance evaluation.

Potential Commercial Applications: High-performance robot arms, when combined with whole-arm manipulation, will be the enabling technology for a large repertoire of new tasks: laying up composite tapes, exploring underwater terrain, aiding ecological restoration programs, and operating in hostile environments.

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098 MSFC
90-1-05.09-0402 NAS8-38914
Self-Contained Miniature Dexterous Hand
Bonneville Scientific, Inc.
918 East 900 South
Salt Lake City, UT 84105
Allen R. Grahn (801-359-0402)

This project will investigate the feasibility of a miniature robotic dexterous hand that would aid in the efficient automation of scientific experiments on board Space Station. The innovative feature of the dexterous hand is a small but powerful piezoelectric motor built into the finger joint to provide finger actuation. The dexterous hand to be constructed in Phase II will have the following features: small size--to fit into confined spaces; low mass--to conserve robot payload; energy efficiency--to ensure low power usage and less heat rejection problems; very simple motor construction--reliable and inexpensive; self-contained actuators--simple mechanical interface facilitates change-out of fingers; ample space in the fingers--to accommodate sensors leads, and electronics; loss of power when the fingers go limp--to facilitate extrication from cavities without damaging surrounding objects; extensive tactile sensing capability--to allow adaptive grasping and dexterous manipulation.

Potential Commercial Applications: The dexterous hand system resulting from this project will have the following applications: automated manufacturing, prosthetics, laboratory studies in dexterous manipulation and grasping, aids to the handicapped, service industry

robots, and telerobotic and autonomous robotics in hazardous areas.

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099 MSFC
90-1-05.09-0718 NAS8-38906
Centerline Imaging Module for Grasping End Effectors
Olis Engineering
P.O. Box 408
Sedalia, CO 80135
Carter K. Lord (303-688-0781)

The purpose of this project is to develop a true centerline imaging module for use with external grasping end effectors. It will design a centerline imaging system for external grasping end effectors, fabricate a prototype of the centerline imaging module, and participate in the testing of the system at NASA-MSFC. The need for this type of imaging system was identified during the course of a previous study to develop inflatable end effectors for handling delicate composite structural components. Since the firm has designed and fabricated an external grasping end effector currently in use at NASA, in conjunction with the P-FMA at MSFC, this unit will be used to evaluate the centerline imaging module to minimize the cost of the project.

Potential Commercial Applications: Applications of this research are nearly as numerous as those for teleoperator systems. The enhanced visual reference of a true centerline imaging system will greatly improve manually directed operations in all fields of teleoperation: military systems, space construction and assembly, satellite servicing, marine exploration, and salvage operations, etc.

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100 MSFC
90-1-05.09-2567 NAS8-38916
Robotic Guidance Systems Using Specialized and Generalized Targets
Cybernet Systems Corporation
1919 Green Road, Suite B 101
Ann Arbor, MI 48105
Charles J. Jacobus (313-668-2567)

Robotic guidance requires sensing and control in three dimensions. This can be accomplished through the use of external sensors that measure robot location relative to target object locations. A robot guidance system will be developed based on hybrid laser illumination and video sensors, that can use simplified targets for both object location and identification, and more complex three-dimensional geometrical, feature-based recognition schemes as well (at the cost of greater computational complexity). Many designed objects like ORUs, tools tailored for robotic use, and satellite-docking fixtures, can easily incorporate docking targets and object coding tags (like bar codes). These recognition "fixtures" offer the advantage of rapid reliable recognition (even in a vision system that can handle more complex recognition tasks) and are analogous to specially designed grapple points, which offer easy, sure robotic grip points. While designed targets are good for manipulation and recognition of designed objects, untagged, geometrical feature-based recognition and measurement must be supported as well. This requirement is necessary for grasping untagged objects, manipulating damaged objects, or aligning objects so that particular features (such as holes, sides, corners, etc.) mate properly.

Potential Commercial Applications: Space, industrial, and military applications of autonomous robotics will become cost effective through the use of more robust vision- guidance systems and object-tagging schemes that support sensorized robot pick and place.

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101 MSFC
90-1-05.09-8500A NAS8-38886
Virtual Reality User-Interface for Actualizing a Robot System
KMS Fusion, Inc.
P.O. Box 1567
Ann Arbor, MI 48106-1567
Jerry L. Turney (313-769-8500)

Time-delays and limited sensory feedback of remote telerobotic systems tend to disorient teleoperators and dramatically decrease the operator's performance. To eliminate these effects, a virtual reality user-interface for actualizing a robot (VIRTUAL-ROBOT) system will be designed. The VIRTUAL-ROBOT system will totally immerse the operator in a simulation of the remote telerobotic environment and will intercept operator commands and provide instantaneous graphical simulation of the effect of the command on the telerobot while relaying the command to the remote telerobot. The system will ensure the integrity of the simulation by using visual updates from the remote environment to correct the simulated environment, if discrepancies between the simulated and remote environment occur.

Potential Commercial Applications: The telerobotic simulator will allow significantly more realistic and more understandable simulations of remote telerobots to be performed. This type of system would greatly benefit ground-based telerobotic operations, as well as those used to remove hazardous waste from remote sites.

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06: Computer Science and Applications

102 LaRC
90-1-06.01-1732 NAS1-19278
Interactive and Adaptive Grid Quality Assessment
Program Development Corp. of Scarsdale
300 Hamilton Avenue, Suite 409
White Plains, NY 10601
Peter R. Eiseman (914-761-1732)

Numerical grid generation represents the critical link that connects numerical, partial differential equation solvers with real-world computational simulations. For aerospace applications, vehicles with complex geometric configurations and solution behavior are to be considered. Block-structured grids have been recognized as

an effective tool for such considerations. Little has been done, however, to assess the quality of the generated grids. In this project, the feasibility of effective grid-quality assessment will be established through the creation of measurement techniques and a prototype code. The prototype code is a deliverable item and would provide the foundation upon which a number of grid-diagnostic tools would arise from subsequent Phase II efforts. The prototype code will present interactive graphical displays of grid-quality objects simultaneously with the grid and the control net through which local grid manipulations would transpire. With the manipulations available for local corrective actions in response to quality indicators, the user would be able to perform interactively adaptive grid cycles. In effect, this would represent a form of interactive computational fluid dynamics. The execution of these latter actions would require rapid networking between the supercomputer and the workstation. Altogether, the grid diagnostic capability would lead to improved numerical simulations.

Potential Commercial Applications: Software tools offering grid diagnostic capability and enhanced adaptive strategies will help engineers and scientists to achieve improved reliability and efficiency in analysis of increasingly complex designs of present and future aerospace systems.

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103 LaRC
90-1-06.01-3304 NAS1-19273
Three-Dimensional Postprocessing for Computational Fluid Dynamics
Amtec Engineering, Inc.
3055 112th Avenue N.E. #208
Bellevue, WA 98004
Byron D. Ponten (206-827-3304)

Computational fluid dynamics (CFD) methods generate vast amounts of numerical data that must be displayed graphically for use. Current graphical computer software programs can display data only on lines or on surfaces defined in the computational grid. CFD software users desire to display CFD data on arbitrary surfaces that may not conform with the computational grid. A software program will be developed that allows users to display CFD data on arbitrary, user-defined surfaces. This program will be based upon the company's existing interactive plotting software called TECPLOT. It will work with data defined in multiblock, finite-difference or finite-element computational grids.

Potential Commercial Applications: The resulting software program will be of great value to the aerospace industry and to the U.S. Air Force.

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104 GSFC
90-1-06.02-4242 NAS5-31407
CASE-Based Timing Assessment Tool
Advanced System Technologies
12200 E. Briarwood Avenue, Suite 260
Englewood, CO 80112
Robert T. Goettge (303-790-4242)

The most critical deficiency with CASE products as applied to time-critical software design is their inability to adequately support the trade-off process involving timing and performance issues. Only a few of the so-called real-time tools support the allocation and budgeting of timing requirements. None of the available CASE tools provide the user with estimates of delivered timing that are derived from the system design and the workload factors. Quantitative feedback regarding the impact of software design decisions on system timing is critical to system success, since virtually every step in the design process can have an effect on performance. This project addresses a solution to this deficiency by integrating state-of-the-art performance modeling techniques with CASE tool software-design models. The technical objectives of Phase I include formalizing a stimulus-response (S-R) diagram representation which is able to support detailed timing simulations and determining compatibility between S-R representation- and state transition-based design representations. State-transition-based design representations (Ward and Mellor, Hatley, ESML, StateCharts, etc.) are being specifically targeted because of their predominance in the CASE user community.

Potential Commercial Applications: A portable, CASE-based timing assessment tool would provide a timely and cost-effective facility for conducting simulations of dynamic response time behavior and would afford developers more visibility of software design trade-offs affecting system performance. A wide range of commercial applications are foreseen as real-time CASE usage increases in the commercial sector.

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105 GSFC
90-1-06.02-5500 NAS5-31408
A General Purpose Nonlinear Dynamics Analysis Package
Swales & Associates, Inc.
5050 Powder Mill Road
Beltsville, MD 20705
William B. Haile (301-595-5500)

Nonlinear structural analysis of large-scale dynamics problems currently can be solved only with cumbersome, complex codes and their attendant lengthy computer run times. However, a very significant percentage of the required problem solutions can be achieved with a much simpler, more efficient methodology. To that end, the work undertaken for this project will develop and implement a general-purpose computer code for the transient solution of coupled structures with linear and nonlinear physical connections. Common problems such as STS/payload trunnion friction effects, booster/launch stand interaction at liftoff, pin-puller gap effects, excitation by stepper motors, and so forth, will be amenable to this approach. The resulting code will

be simple to use in the aerospace dynamics community and greatly reduce user input and computer run times. In addition, solutions will be available on the non-super mainframe machines, such as MicroVAXs, and even on PCs.

Potential Commercial Applications: Software developed in this project will efficiently and cheaply solve many of the nonlinear flexible dynamics problems occurring in the aerospace community, as well as in other industries such as automotive, high-speed rail, reciprocating machinery, etc.

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106 GSFC
90-1-06.02-5700 NAS5-31382
Creation of a NASA Specification to Executable Programs (NASA/STEP) Capability
International Software Systems, Inc.
9430 Research Boulevard, Suite 250
Austin, TX 78759
Don Hartman (512-338-5722)

Support for software development within the system engineering process is a widely recognized problem. The goal of this project is to deliver a NASA domain-specific specification-to-executable-programs (NASA/STEP) capability based on the evolving Strategic Defense Development System (SDDS). The SDDS capability currently exists in prototype form but is strongly oriented to the strategic defense software domain. It automatically translates graphical models (specifications) into third-generation computer programming languages for test and verification. The graphical models can be decomposed, analyzed, and evolved as knowledge of software requirements and design evolve. Instrumentation of the models can permit test and verification of the software during each iteration. The models may be displayed, tested, or stored in their various levels, thus increasing human understanding, management control, requirements analysis, and design specification, as well as reusability of the software. The Phase I objectives are to identify the specific requirements of NASA regarding use of the STEP technology to develop large-scale, complex software systems. The Phase II effort would be to deliver a prototype NASA/STEP. The expected benefit to NASA is an acquired technology and the capability to more efficiently support the space software-systems life cycle.

Potential Commercial Applications: As the STEP approach to software development is not specific to either technical or business applications, use of this approach to software development would be of significant interest across the United States in many commercial markets.

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107 LaRC
90-1-06.03-2020 NAS1-19253
An Intermediate Language for Formal Verification Tools
Odyssey Research Associates, Inc.
301-A Harris B. Dates Drive
Ithaca, NY 14850-1313
Douglas Harper (607-277-2020)

This project will investigate an intermediate formal language for integrating formal verification tools. Such a language would allow different tools such as theorem provers, decision procedures, and formula generators to be used in the same environment, either by translating the various tools' formal languages into the intermediate language and back or by using the intermediate language as an internal form shared between tools. The ability to integrate different verification tools will significantly enhance the utility of formal verification in developing reliable software. The project objectives are to formulate a candidate intermediate formal language and to define translation algorithms among the intermediate language and the two existing formal languages from different formal verification environments. The approach will be to examine a collection of formal languages from existing formal verification environments and to formulate a candidate intermediate language expressive enough to translate the existing languages into. It will then choose two existing languages from different environments and define algorithms to translate them into the intermediate language, and back. This will demonstrate the feasibility of the intermediate language for connecting different tools. The results will be a candidate intermediate language and the translation algorithms.

Potential Commercial Applications: Formal verification environments and tools integrated into existing software engineering can be marketed as products in their own right or be used to produce high-quality, reliable software products.

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108 LaRC
90-1-06.03-3474 NAS1-19252
A Testing Methodology for High Reliability Software
Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, MA 02138
Alper K. Caglayan (617-491-3474)

Since software is a crucial component of current engineering systems, high-reliability software is required for NASA programs. The use of formal software engineering principles and of CASE tools have yielded only modest progress in this area. The use of redundant software components is not sufficiently developed to provide an efficient alternative. A testing methodology will be developed that will produce high reliability software by using interactive, proof-based correctness testing, enforced testing diversity, and knowledge-based testing. This methodology is applicable to parallel software as well. Recent redundant software experiments indicate that no single testing strategy produces sufficient test cases to ensure high reliability. Hence, a combination of testing strategies is required for high

reliability. Experimental research also indicates that dynamic testing is inefficient in detecting failures that occur infrequently. Knowledge-based static testing is more efficient. Oracles for asserting correctness of high-reliability software are difficult to build since their reliability must exceed the software. The firm has developed a generalization of interactive proofs which solve this problem. In the future, parallel architectures will be used for critical software applications.

Potential Commercial Applications: An integrated testing tool general enough for testing any real-time, embedded applications for which high reliability is a requirement would apply to high-availability systems such as tactical systems, commercial transaction processing, and aerospace applications. This will fulfill the urgent need for testing of parallel software as well.

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109 ARC
90-1-06.04-5810 NAS2-13340
Decision-Theoretic Control of Artificial Intelligence Scheduling Systems
Heuristicrats
1678 Shattuck Avenue, Suite 310
Berkeley, CA 94709-1631
Othar Hansson (415-845-5810)

A prototype decision-theoretic scheduler (DTS) will be developed that employs state-of-the-art probabilistic inference technology to expedite the search for efficient solutions to constraint-satisfaction problems. The approach involves assessing the performance of heuristic control strategies, which are normally hard-coded into scheduling systems, and using probabilistic inference to aggregate this information in the light of a given problem's features. The company recently introduced a similar approach to solving single-agent graph search problems, yielding orders-of-magnitude improvement over traditional search algorithms on a classical test domain. Recent work in the constraint-satisfaction community suggests that this advantage may be even more dramatic when applied to typical scheduling problems. In addition, DTS promises to provide a richer framework for human scheduling experts to express declaratively conflicting multi-attribute objectives that their schedules must satisfy.

Potential Commercial Applications: The scheduling of multiple tasks that compete for scarce resources is an important, ubiquitous problem in scientific, industrial, and military domains. A general-purpose, interactive scheduling assistant and subroutine library for use in artificial intelligence systems will be marketed.

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110 JSC
90-1-06.05-0885 NAS9-18475
Language Engineering in Speech Recognition
Speech Systems, Inc.
18356 Oxnard Street
Tarzana, CA 91356
David J. Trawick (818-881-0885)

Speech recognition technology can be used for interacting with a computer by speaking to it. Continuous speech and large vocabularies create the need for a language model to resolve words and phrases that sound alike. In some applications, it is necessary to "engineer" a language to deal with the computer, a language that is a part of English but is not based on an impractical assumption that the system will be able to deal with the unconstrained use of English. This project will develop tools that facilitate such language engineering. The resulting language, having a formal definition, can be readily interpreted by expert systems or other computer applications. Useful speech recognition applications can be practically developed, creating new freedom and power in the use of computers or in the control of machines. In particular, the approach involves designing and implementing a "gated graph" approach that will simplify the process of creating the language model. The gated graph will allow conditions of language (like matching singular and plural cases) to be handled more efficiently in developing and maintaining a language model. The result will be compatible with the company's commercial speech-recognition system.

Potential Commercial Applications: Commercial and governmental use of speech recognition will appear in such areas as medical transcription, training, interaction with expert systems, voice control of equipment, and database access.

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111 JSC
90-1-06.05-1010 NAS9-18459
Fuzzy Cognitive Maps for Mission Planning and Flight Control
Tacan Corporation
2330 Faraday Avenue
Carlsbad, CA 92008
Dennis J. Toms (619-438-1010)

The fuzzy cognitive map, a neural-network approach to knowledge representation, has several characteristics that make it highly attractive for use in planning and control tasks: ease of combining knowledge acquired from various sources; a capacity for adaptive refinement through supervised and unsupervised learning; and an ability to make very high speed inferences in both routine and novel situations. This project will assess the potential of the fuzzy cognitive map as a principal form of knowledge representation in planning and control systems. In such systems, fuzzy cognitive maps could assume some of the functions currently handled by human experts, assuring a faster, more consistent response. Phase I will consist of an analysis of the fuzzy cognitive man as applied to planning and control, a comparison to other AI techniques, particularly expert systems, and a proof-of-concept demonstration centered on a selected problem area.

Potential Commercial Applications: Applications include such areas as smart robotic control, reactor and plant control, and automated manufacturing.

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112 JSC
90-1-06.05-1986 NAS9-18485
Real-Time Expert Systems
Integrated Software, Inc.
P.O. Box 060295
Palm Bay, FL 32906-0295
William Wavering (407-984-1986)

This project will develop a guaranteed-performance, hard, real-time expert system for the eventual support of real-time mission planning and control for flight operations of the Shuttle Orbiters and of the Space Station Freedom. The objectives are to determine the feasibility of using an innovative scheduler, in combination with an approximate reasoning technique, as a means to schedule expert-system rule processing in a way that guarantees a hard, real-time response time from an expert system; to determine which approximate reasoning technique--progressive deepening, progressive reasoning, time-constrained inference, or other--is most appropriate to use with the scheduler; and to develop a design for a real-time planner for Shuttle Orbiter and Space Station Freedom orbital docking procedures as a domain in which to study possible performance improvements. The project will determine an improved method for scheduling the order of processing rules and facts in response to a real-time input and will apply innovative management of the (usually) limited computing resources in embedded applications.

Potential Commercial Applications: This research project covers a wide range of applications from factory robotics to aircraft and automobile collision avoidance systems.

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113 JSC
90-1-06.05-3550 NAS9-18478
Digital, Video-Interactive-Based, Intelligent, Computer-Assisted Training/Mission Planning System
Betac Corporation
7323 Highway 90 West, Suite 510
San Antonio, TX 78227
Joseph P. Vasile (512-675-3550)

A prototype digital, video-interactive-based, intelligent, computer-assisted training system (DVI-ICAT) or mission planning system will be developed. The system will serve both as a launching point for further Phase II work on the system and for demonstrating to NASA/JSC the capabilities and potential applications of DVI to training and mission planning. This system will use DVI technology to present the trainee/mission planner with a series of highly realistic interactive simulations of the subject area. The system makes extensive use of the unique multimedia presentation capabilities offered by DVI, including full-motion color video, high resolution still imagery, three-dimensional graphics, and multiple audio channels. The intelligent tutoring component will be integrated into the simulation and will include dynamic models of the trainee, expert, and tutor. The user interface will be supported by writing extensions to the DVI software library and building upon work currently underway at the firm in the area of DVI-ICAT. The ITS structures and knowledge bases will be built using object-oriented design methodologies and commercially available expert- system development tools.

Potential Commercial Applications: Systems that can provide simulations and intelligent autonomy are expected to reduce total costs due to reduced human training costs. DVI should fill a void that exists between costly high-fidelity training systems and low-fidelity PC-based systems. The multimedia capabilities of DVI systems will respond to the complex technical challenges in the training and simulation industry.

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114 ARC
90-1-06.06-5682 NAS2-13351
Interactive, Three-Dimensional Flow Solver Software Project
Visual Computing, Inc.
883 N Shoreline Boulevard, #B-210
Mountain View, CA 94043
Jeffrey Q. Cordova (415-961-5682)

This project concerns the design of an interactive flow solver software technology. The novel aspects include the development of a network-compatible software environment for computational fluid dynamics (CFD), the focus on interactivity and on real-time response, and the design of graphical user interfaces for scientific computation. The project objective is to develop a capability for interacting with a three-dimensional Euler solver in real time. A successful effort will establish the possibility of building interactive CFD software for a CRAY-SGI-Ethernet-TCP/IP-UNIX-ARC3D combination.

Potential Commercial Applications: The software produced from this effort, combined with interactive grid generation software, will allow end users to significantly reduce time spent in the CFD design cycle and provide scientists with a common numerical laboratory for CFD.

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115 ARC
90-1-06.06-7450 NAS2-13353
A Full-Resolution, Autostereoscopic Display with Hologram-Like "Look Around" with a Wide Viewing Zone
Dimension Technologies, Inc.
176 Anderson Avenue
Rochester, NY 14607
Jesse B. Eichenlaub (716-442-7450)

The Phase I plan is to build a proof-of-concept model for a full-resolution, autostereoscopic LCD display. It will use a super-fast, ferroelectric LCD in combination with an innovative flat-panel, LCD-based autostereoscopic three-dimensional display technology that requires no glasses. Two important features will be implemented: an expanded viewing zone and a hologram-like "look-around" capability. Both of these functions will be realized by passive means, that is, without tracking the position of the observer's head. These improvements are important in the proposed application of visualizing complex fluid flow phenomena and in other scientific applications. They will allow the viewing of images by

several observers simultaneously, remove restrictions on head movements, and for the first time allow non-holographic, three-dimensional imaging in which different views of the object or scene would be visible, depending on the observer's perspective.

Potential Commercial Applications: Improved three-dimensional displays are needed in scientific visualization, mathematical and molecular modeling, geographic information systems, photogrammetry, industrial inspection, CAD/CAM, architecture, medical imaging, and other applications.

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116 JPL
90-1-06.07-8854 NAS7-1126
Time-Warp Concurrency Control for Database Systems
Integrated Parallel Technology
5994 West Las Positas Blvd, Suite 209
Pleasanton, CA 94588
Calvin A. Buzzell (415-734-8854)

Multiprocessors are able to use optimistic-execution protocols such as time warp for large-scale, asynchronous applications. Lack of a working optimistic database concurrency scheme based on the time-warp concurrency scheme prevents optimistic application systems from achieving a high degree of concurrency. This project provides for a unified database caching and concurrency control algorithm based on the time-warp algorithm. First, a unified framework for both caching and concurrency control for a database environment will be developed based on a time warp. The basic time-warp paradigm will be modified, as required, to achieve the greatest possible concurrency. Additionally, the paradigm will provide for nested transactions to allow the greatest degree of concurrency possible within database transactions. To evaluate the proposed algorithms, a discrete-event simulation of the database concurrency scheme will be modeled on a multiprocessor using the object-oriented language C++.

Potential Commercial Applications: A successful development effort will provide optimistic-execution applications running on multiprocessors, that is, discrete-event simulations, a mechanism for rapid and efficient processor access to data on large databases stored on one or many mass storage devices.

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117 GSFC
90-1-06.08-1700 NAS5-31409
Spacecraft Supercomputer
Omitron, Inc.
6305 Ivy Lane, Suite 500
Greenbelt, MD 20770
Patrick H. Stakem (301-474-1700)

This project will develop a spacecraft supercomputer (SSC) for future NASA missions. The SSC would have computational capabilities at least an order of magnitude greater than current flight architectures. By using existing or emerging microprocessor technology and a novel connectivity architecture, it would provide sufficient memory and communication bandwidth resources for many spacecraft and payload requirements. The goal is to demonstrate a prototype SSC in a realistic flight-operations environment with minimal risk and cost. This would be best accomplished as a flight experiment on a Hitchhiker (HHG)- class mission. The SSC's flexible architecture and use of extremely fast microprocessors would enable it to handle a wide range of computational problems such as onboard processing of instrument data, data compression, and sensor and control system management. The Phase I effort will establish the feasibility of the preliminary design and will select a proposed HHG-class mission for the demonstration. Phase II work would consist of completing the detailed design, prototype fabrication, testing, and integration. The SSC can provide increased computational capability for future NASA programs employing high-data-rate instruments or large clusters of medium-rate instruments.

Potential Commercial Applications: SSC applications include manufacturing process control, communication system management, medical research, and image processing.

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118 GSFC
90-1-06.08-8211 NAS5-31402
Space Flight Supercomputer
Irvine Sensors Corporation
3001 Redhill Avenue, Bldg 3 #208
Costa Mesa, CA 92626
John C. Carson (714-549-8211)

This Phase I effort will design a three-dimensional packaged Flight Supercomputer. The supercomputer will be based on a parallel processing architecture with a programmable topology that will allow optimum performance with a wide range of programs. The firm will complete this preliminary design in accordance with specific spacecraft application guidelines obtained from the sponsor; the result will be a demonstration recommendation for the processing unit during Phase II. The Phase I analyses will establish system requirements and constraints, and determine the feasibility of constructing a three-dimensional processing module. The firm plans to complete performance predictions for the ultimate system and a preliminary Phase II program plan. The firm also plans to develop preliminary specifications for a Phase II breadboard demonstration of the Flight Supercomputer that would include estimates of total electronics volume, weight, and power budgets as a function of degree-of- processing power. Thermal issues will also be addressed.

Potential Commercial Applications: Desktop and portable supercomputers.

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119 KSC
90-1-06.09-1692B NAS10-11764
Artificial Intelligence Techniques for Scheduling Shuttle Processing
Stottler Henke Associates
3254 Beach View Way
Melbourne Beach, FL 32951
Andrea Henke (415-595-1692)

An innovative combination of artificial intelligence (AI) techniques will be investigated to meet NASA's scheduling needs for representation, schedule design, and schedule analysis. AI knowledge representations such as frames, semantic networks, and rules will be used for capturing schedule components and constraints. Schedule design will be facilitated through the use of similarity-based and constraint-satisfaction techniques. NASA's schedule analysis capabilities will be enhanced through the application of AI constraint-based techniques, capture and implementation of heuristic analysis techniques, and standard graph negotiation techniques. The goals of the Phase I research are to define thoroughly the mission-planning domain, elaborate the artificial intelligence techniques useful for automating the scheduling problem, prove the feasibility of these techniques, and develop a complete system specification for an automated NASA shuttle and payload processing scheduler. Phase I research and prototype development will lay the groundwork for the Phase II implementation of an automated scheduling and analysis system.

Potential Commercial Applications: Large-scale scheduling applications in the commercial sector could benefit from an automated schedule design and analysis tool for manufacturing, delivery, construction, and project scheduling.

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120 KSC
90-1-06.09-3633 NAS10-11763
Integrating and Coordinating Intelligent Planning and Scheduling Tools
Symbiotics, Inc.
875 Main Street
Cambridge, MA 02139
Richard M. Adler (617-876-3633)

Current automated planning and scheduling tools are generally single-user, largely "stand-alone" systems based on heterogeneous languages, development tools, and processing platforms. Domain models (e.g., of tasks, resources, and constraints) are typically incompatible across systems. Interfaces to users, databases, and other decision and operations support tools tend to be custom-built and difficult to extend. The goal of this effort is to design an innovative framework for integrating and coordinating intelligent and conventional systems non-intrusively with each other and with multiple users to support concurrent, distributed solution of large planning and scheduling problems. The effort will build on previous work on advanced, object-oriented tools for distributed communication, control, and information modeling. Uniform representational models and mapping capabilities will be designed for transparently moving data, knowledge, and control structures across disparate tools and information stores. Knowledge-based, cooperative control capabilities will be applied to manage access to work elements, route tasks to suitable human or tool servers, and detect and help resolve inconsistencies across elements of master schedules or plans. These advanced integration and coordination capabilities will enhance the quality and productivity of planning and scheduling activities for shuttle operations and other NASA missions.

Potential Commercial Applications: Architectures for integrating and coordinating software systems for automating decision and operations support have commercial applicability for manufacturing process control and for communications, computer, power, and transportation networks.

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121 KSC
90-1-06.09-4122 NAS10-11760
Automated Operations and Maintenance Instructions System
ENSCO, Inc.
5400 Port Royal Road
Springfield, VA 22151-2388
Gregory E. Taylor (407-254-4122)

Technical and management personnel at NASA's Kennedy Space Center of NASA need an automated system for the management of Operations and Maintenance Instructions (OMI) associated with Shuttle Transport System (STS) ground processing. Currently, OMIs are generated, used, and maintained largely through a paper-driven process. An innovative system will be designed that is capable of: ingesting existing OMI text and related data into an indexed archive of OMIs; quickly retrieving OMIs and displaying information tailored to various classes of users; and accepting electronic signature input and verification of delivered OMI tasks. Such a system will integrate artificial intelligence techniques, database management, and hypermedia. The expected benefits to NASA are reduced paper use, increased productivity of technical personnel, and greater assurance to management that operational and maintenance procedures are properly executed and sequenced.

Potential Commercial Applications: An automated OMI System could be used to automate documented work instructions or paper-based manuals, especially those for hazardous operations such as handling explosives, chemicals, or fuels. These applications exist in the commercial aerospace industry, the nuclear power industry, and in electronics and chemical manufacturing plants, as well as in the logistics branches of the military services and other governmental agencies.

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122 ARC
90-1-06.10-4176 NAS2-13344
General Purpose, Optical, Vector-Matrix Multiplier
Opticomp Corporation
P.O. Box 10779
Zephyr Cove, NV 89448
Peter S. Guilfoyle (702-588-4176)

A general purpose, optical, vector-matrix multiplier will be devised to compute 256X256 element matrices times 256-element vectors at 8-bits precision in less than 100 microseconds. This project will take an innovative architectural approach that uses two 64-channel acousto-optic devices operating at several hundred megahertz per channel in a telecentrically imaged configuration. The use of laser diode arrays, computer-optimized optical systems, multichannel gallium-phosphide AO devices, and 128-channel hybrid avalanche photodiode arrays with processing electronics, coupled with an innovative "systolic" data flow optimized for the hardware, allows performance projections well within NASA's requirements. The machine architecture is focused to the solution of simultaneous equations for the matrix-inverse problem. Anticipated use is ultimately in a feedback control system to calibrate NASA multiple 256-element mirror arrays.

Potential Commercial Applications: This multiplier could be applied in seismic signal processing, aerodynamic modeling, and simulation of image processing.

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123 LaRC
90-1-06.11-0700 NAS1-19275
Optimization of Large Structures in a Massively Parallel Environment
MRJ, Inc.
10455 White Granite Drive, Suite 200
Oakton, VA 22124
Rong C. Shieh (703-385-0792)

This project will provide an innovative approach to design problems in structural analysis through the efficient use of the Connection Machine and through new optimization techniques for SIMD architectures. Project objectives will be to develop a super-efficient, general-purpose, analytical/computational tool (computer code) on the massively parallel CM-2 computer system. This tool can be used for methodological research and for applications in structural design analysis and optimization; it can also be extended to multilevel and/or multidisciplinary optimization. An existing efficient, general-purpose, nonlinear optimization code will be adapted, and a massively parallel, finite-element analysis/reanalysis procedure for large structures will be formulated. The end products will be several efficient, massively parallel structural analysis/optimization algorithms and an associated general-purpose prototype computer code (or code system).

Potential Commercial Applications: The massively parallel, structural analysis algorithms and an associated general-purpose CM-2 computer code or code system will be particularly useful in design analysis/optimization of large (or small) aircraft and aerospace structures, for which minimum weight and/or pointing accuracy design are of primary importance.

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124 LaRC
90-1-06.11-1123 NAS1-19255
Software for Multidisciplinary System Optimization
Modeling and Computing Services
1153 Bordeaux Drive, Suite 107
Sunnyvale, CA 94089
Ernest D. Eason (408-745-1123)

A software product for planning and executing multidisciplinary analysis and synthesis of complex engineering systems will be developed. The software is based on a network decomposition theory, with strong consideration of the practical organizational constraints on multidisciplinary system optimization. It includes parallel processing features and an expert system for planning applications. The software is intended to be used in all phases of system development, from preliminary planning through detailed system optimization. The objective in Phase I is to demonstrate the feasibility of the decomposition theory and the proposed innovative implementation. Several sample problems will be solved to prove feasibility and explore the characteristics of the approach.

Potential Commercial Applications: The product could be used in government commercial ventures, particularly for vehicle development projects, requiring goal-directed planning and development of complex technical systems for aviation, aerospace, automotive, and defense.

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07: Information Systems and Data Handling

125 LaRC
90-1-07.01-0888 NAS1-19268
A Spectro-Imager
Microtronics Associates, Inc.
4516 Henry Street, Suite 403
Pittsburgh, PA 15213-3728
Darryl D. Coon (412-681-0888)

This project will focus on the design and hardware development of a spectro-imager that will be developed and tested under Phase II. Processing of multispectral image information will be performed in a two-dimensional parallel asynchronous mode by the spectro-imager. To acquire and process the spectral information flowing to each pixel in parallel, a new technological stratagem will be required; the approach will use rather simple neuron-like transient sensing circuits coupled to each pixel. These circuits will be optimized to respond at the frequency of a chopper in the optical portion of the system. A computer-controlled, circular, variable filter will also be located in the optical portion of the system, to permit the acquisition of spectral information from multispectral, focal plane sensors. The spectral resolution will be sufficient for geochemical imaging, planetary exploration, and other imaging applications. Such applications will be explored in conjunction with the development work.

Potential Commercial Applications: Applications should include improved geological survey sensitivity and

resolution, enhanced multispectral target identification and discrimination, and marked performance gains for ground, airborne, and space-based FLIR systems.

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126 LaRC
90-1-07.01-9271A NAS1-19265
Focal Plane Image Compression in the Charge Domain
Altadena Instruments Corporation
55 North Saint John Avenue
Pasadena, CA 91103
Thomas Soulanille (818-405-9271)

This project addresses charge-domain image compression on a monolithic charge-coupled device (CCD) detector. Such a device would have substantially reduced output bandwidth compared with existing pixel-by-pixel readout systems. Because current image compression algorithms can provide compression factors of greater than 10:1 with little visible degradation, a charge-domain compressor CCD could reduce system electronics mass and power requirements by an order of magnitude without compromising image quality. The objectives of this project are to devise an image compression algorithm that can be implemented in the charge domain and to produce an electrical design for a CCD that implements the compression algorithm and a block design for the system that incorporates it. The effort will develop a software simulation of a charge-domain compressor, use the simulation to optimize the compressor performance, determine the optimal partitioning between on-chip and off-chip, and estimate the power required for such a system. Potential NASA uses for a charge-domain image compressor CCD include minimizing electronics resource requirements for very high resolution (e.g., landing site selection) and very small (e.g., rover and penetrator) planetary mission cameras.

Potential Commercial Applications: Potential commercial applications for CCD charge-domain image compressors/detectors include spaceflight imaging systems, electronic (i.e., non-film-based) motion picture systems, and consumer video cameras.

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127 GSFC
90-1-07.02-6207 NAS5-31422
Application of EOFs to Multispectral Imagery Compression
Atmospheric & Environmental Research
840 Memorial Drive
Cambridge, MA 02139
Ross N. Hoffman (617-547-6027)

Increases in information bandwidth using communication channels of fixed physical bandwidth are made possible by eliminating redundant information in the information stream using data compression-decompression algorithms. Images--especially multispectral or color images--put the greatest strain on communications channels. A variety of existing techniques, of varying maturity, may be applied to the problem of image compression. Several of these techniques may be applied to multispectral images, but they are less than optimal. The approach in this project first compresses the data spectrally to derive orthogonal images with minimum bit depth. This technique is adaptive and makes use of empirical orthogonal functions. After being spectrally compressed, the data are further compressed using standard techniques, such as transform coding, vector quantization, and DCPM. The efficiency of the loss schemes studied will be assessed by standard statistical measures, as well as by considering the effect of the compression on end-user algorithms, such as cloud parameter extraction and spectral feature identification.

Potential Commercial Applications: High rates of data compression and, in particular, spectral compression are important for new and planned sensors with high spectral resolution and data rates.

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128 GSFC
90-1-07.02-7253 NAS5-31410
A Scientific Array Data Management System
Ken Wanderman & Associates, Inc.
160 Bement Avenue
Staten Island, NY 10310
Ken Wanderman (718-273-7253)

NASA maintains an extraordinary quantity of scientific data in multitype n-dimensional arrays. Examples can be found in NASA Climate Data System (NCDS) and Flexible Image Transport System images. A significant problem is that no universal management system exists for this data. This project will build a scientific array data management system (SADMS), which will contain software tools to browse, query, and obtain graphical representations, as well as perform computations on data independent of its format. Tools will be available at high-level language, command, and menu levels. System builders can easily build their own applications using the tools provided; users can use the native front-end or supply their own. At its core, SADMS will use the NASA-developed Common Data Format plus NCDS enhancements. SADMS will greatly reduce the development time of new applications, resulting in significant cost savings to NASA. Existing technology such as graphical display in NCDS could be used as is. Thus, SADMS provides a flexible universal access tool for all scientific array data. Phase I includes the design of SADMS, creation of a subsystem prototype, and a demonstration of how SADMS can support the construction of applications on typical data. Phase II would involve the full implementation of SADMS.

Potential Commercial Applications: The SADMS will appeal to any group with large amounts of scientific data, including the scientific communities in business, academia, and government.

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129 SSC
90-1-07.04-8707 NAS13-436
An Integrated GIS and Statistical Data Analysis System
Statistical Sciences, Inc.
P.O. Box 85625
Seattle, WA 98145-1625
Keith Kerr (206-322-8707)

An integrated Geographic Information System (GIS) and interactive statistical language and system (ISLS) will be developed. The current analytic capability of GIS systems does not include modern graphical data analysis and statistical inference of multidimensional data. This project addresses the need for greatly increasing the analytical capability of GIS technology. It will also address the issue of efficient conversion of data structures as an essential ingredient of an integrated GIS/ISLS. The project objectives include the development of a fully functioning prototype integrated GIS/ISLS, with an initial basic set of graphical data analysis and statistical methods for multivariate data that is accessible via user-friendly interface based on the X Windows System and Motif. These efforts will focus on the use of GRASS and S-PLUS as the basic building blocks for the integrated GIS/ISLS. In particular, they will focus on developing the necessary software modifications for running GRASS from S-PLUS, and allowing efficient data conversion from GRASS to S-PLUS and back.

Potential Commercial Applications: Statistical and graphical data analysis capabilities will be useful to NASA, other government agencies, and commercial organizations concerned with GIS data.

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130 SSC
90-1-07.04-9000 NAS13-441
An Expert System Interface for Knowledge-Based Image Classification and GIS Modeling
Erdas, Inc.
2801 Buford Highway, Suite 300
Atlanta, GA 30329
Stephen L. Sperry (404-248-9000)

The aim of this project is to design a new module for the firm's raster-based Image Processing and Geographic Information System (GIS) software. The concept will be used to enhance standard digital vector land-use maps using a knowledge-based expert system that accesses available GIS data sources, such as satellite imaging, topographic data, soil data, and hydrology. The focus will be on an interface to an existing expert-system shell. The intention is build on previous studies with rule-based land-use classification. The knowledge-based module will query the user about the rules decision, store and modify the decision rules, and write the macro needed to decide the final land-use classification. The innovation of the program will be to enhance today's image-processing techniques in cases where the land-use classification will be determined by a polygon-specific, and not pixel-specific, classifier. The module will rely on spatial rasters and auxiliary data to duplicate products now produced by traditional airphoto interpretation. The classification rules will be developed using the firm's raster-based GIS.

Potential Commercial Applications: Classified satellite imagery may be put into a GIS database fast and with less reliance on scientific understanding of spectral analysis. This innovation will significantly reduce the time and effort spent putting land-use data into a digital database and increase the analytic capability of GIS technology.

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131 SSC
90-1-07.05-1813 NAS13-434
The Display and Analysis of Variable Resolution Spatial Data in a GIS Environment
Delta Data Systems, Inc.
131 Third Street
Picayune, MS 39466
Andrew Rost (601-799-1813)

The establishment of resolution independence is the foundation of an integrated, format-independent, GIS-processing environment. Resolution independence means that raster data of any pixel dimension, coexisting with (theoretically) "dimension free" points and lines, may be stored and processed in a GIS environment. It removes the requirements for physical resampling and data file integration processes that contribute to unmanageable system overheads for storage and processing in large-scale spatial analysis projects. Phase I will establish the feasibility of resolution-independent processing and examine its implications for database management, mixed data type processing (raster and vector), and input-storage-output operations (hardware). The results would be applied to a Phase II effort directed toward a system-level integration of resolution-independent raster, vector, and attribute data processing in a GIS context.

Potential Commercial Applications: Software design innovations will provide the foundation of a technical and competitive advantage for commercial GIS products used in large-scale resource exploration and management projects.

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132 LaRC
90-1-07.06-0760 NAS1-19276
Novel Optical Interconnect Topologies for Digital Multiprocessors
SCS Telecom, Inc.
107 Haven Avenue
Port Washington, NY 11050
Gary R. Lomp (516-883-0760)

In this project, a novel optical interconnect topology for a digital multiprocessor environment will be implemented. The optical interconnect topology promises to relieve problems existing in the present electronic and optical interconnect networks for the single-instruction-multiple-data (SIMD) computer architecture. For an interconnect among all processing elements (PEs), this unexplored optical interconnect topology promises several important advantages over the conventional

rectangular array topology, such as the use of space-invariant optical elements, identical interconnect latency, and network reconfigurability.

Potential Commercial Applications: This opto-electronic interconnect topology could improve interconnect efficiency for digital computing and for various signal-processing applications such as FFT hardware implementations. Other important applications include neural networks, vision, and artificial intelligence.

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133 MSFC
90-1-07.07-7000 NAS8-38903
Advanced Multisensor, Data-Resources Management System
SRS Technologies
990 Explorer Boulevard NW
Huntsville, AL 35806
Jeffrey S. Yalowitz (205-895-7000)

The objective of this project is to investigate new automated, multisensor, data-resources management techniques for analyzing geophysical and meteorological explorations involving concurrent observations from diverse sensor systems. Emphasis will be placed on advanced data fusion, artificial intelligence, and relational database techniques to perform event recognition and data association. The approach uses an artificial neural-network preprocessor and a knowledge-based system in tandem to correlate and associate multiple source databases and to create object-oriented data structures for event descriptions and mapping of data interrelationships.

Potential Commercial Applications: An automated system to associate data from multiple sensors and to enhance capabilities for recognizing significant events in meteorological and geophysical observations would have multiple applications for analyzing large sets of sensor data in earth sciences, weather forecasting, military command and control, and other fields.

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134 GSFC
90-1-07.08-7978 NAS5-31383
Universal Book Management System
Advanced Applications Corporation
3 Woodsend Place
Potomac, MD 20854
Minze V. Chien (301-424-7978)

NASA space scientists tend to use integrated data of multiple types. For example, the observations collected by the EXOSAT Satellite are made up of database rows, images, spreadsheets (spectra, lightcurves), text indexes, etc. Also, the different data types come from heterogeneous management systems. For example, databases may be stored in Ingres, Sybase, or Oracle; text in Troff, Tek, or ASCII. The purpose of this project is to develop a universal book management system (UBMS) that presents a global view of integrated data types in terms of a virtual "book" object. It will be built atop the NASA-developed DAVID system to support data access from heterogeneous management systems. In addition, UBMS will support program-callable utilities, so that user-specific applications (e.g., a High-Energy Astrophysics Science Archive Research Center) can be built from it. In Phase I, the UBMS will be designed, a subsystem prototype will be built and demonstrated on a relevant multiple type data set (e.g., EXOSAT date), and a presentation will illustrate how UBMS can support the building of user-specific applications. The thrust of Phase II would be the implementation of the UBMS design developed in Phase I and its integration with the NASA-developed DAVID system for accessing heterogeneous distributed data.

Potential Commercial Applications: Results of this project could benefit current NASA and other similar applications. Time, manpower, and cost savings--along with the flexibility and simplicity for access of multiple-type heterogeneous, distributed environments--could be major benefits of this work.

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135 JPL
90-1-07.09-3088 NAS7-1124
Three-Dimensional, Stacked, Optical Memory Based on Polarization Holography
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Gajendra Savant (213-320-3088)

A novel, ultra-dense memory system using three-dimensional optical holographic storage will be developed based on new polarization-sensitive polymer material and polarization holographic technology. This approach represents the first practical attempt to record and retrieve information holographically in three dimensions. Although three-dimensional in nature, the classical, holographic, angular-multiplexing technique cannot effectively use the third dimension because of basic limitations in the optical system. This approach solves the problem by using polarization switching to address the third dimension. The objective of the project is to apply birefringent memory technology to fabricate ultrahigh-density optical storage systems with multiple dimensions. The memory system is a sandwiched structure with alternating layers of polarization-sensitive holographic media. Electro-optic polarization switches act as the selective access to each memory layer and are controlled by the operational modes of the polarization switches. Upon the completion of this research, a three-dimensional, stacked, optical memory system with Terabyte (10^{12} bytes) storage capacity and 10^{12} bytes/nanosecond random access rate will be demonstrated. The system will greatly improve the on-board data storage capacity of NASA's spacecraft.

Potential Commercial Applications: This technology could be applied in optical memory systems for on-board data storage on space missions, as well as in electromagnetic jamming-resistant information storage disks, computer memories, and archival storage systems.

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136 JPL
90-1-07.09-8211 NAS7-31384
Spacecraft On-Board Information Extraction Computer
Irvine Sensors Corporation
3001 Redhill Avenue, Bldg 3 #208
Costa Mesa, CA 92626
John C. Carson (714-549-8211)

The Phase I effort will design a three-dimensional packaged, parallel processing module. This preliminary design will adhere to specific spacecraft application guidelines obtained from the sponsor, and result in a demonstration recommendation for the processing unit during Phase II. The Phase I analysis would establish system requirements and constraints, and determine the feasibility of constructing a three-dimensional processing module. Performance predictions for the ultimate system and a preliminary Phase II program plan will be provided. The preliminary specifications will include estimates of total electronics volume, weight, and power budgets as a function of degree of processing power. Thermal issues will also be addressed.

Potential Commercial Applications: Applications include desktop and portable supercomputers.

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137 GSFC
90-1-07.10-1212 NAS5-31384
NASTRAN on Massively Parallel Computers
RPK Corporation
P.O. Box 1189
Athens, GA 30603
W. Keith Brown (804-642-5518)

The finite-element approach to structural analysis has been considered efficient and comprehensive for many years. The NASA- developed structural analysis program NASTRAN is in the forefront for use in such analyses. In this project, a design that would allow NASTRAN to work efficiently on computers that have a massively parallel architecture will be studied. The effort will include an analysis of the capabilities of existing computers with a massively parallel architecture, determination of efficient matrix algorithms, determination of areas of code that could be executed in parallel, determination of possible parallelization at the NASTRAN command language level, and a definition of the additional NASTRAN I/O functions and executive control functions required to install optimal parallelization techniques.

Potential Commercial Applications: NASTRAN is heavily used by governmental agencies (NASA, Navy, Air Force, Army, etc.), aerospace companies, automobile companies, scientific laboratories, and a host of engineering companies. A parallel version of NASTRAN will, therefore, be useful in the future.

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138 JPL
90-1-07.11-2567 NAS7-1139
A Computer-Based Information Management System for JPL Image Data
Cybernet Systems Corporation
1919 Green Road, Suite B 101
Ann Arbor, MI 48105
Ruth Ross (313-668-2567)

Using the data from planetary exploration now available through NASA and JPL, this effort targets elementary and secondary school students, meeting the needs of young people of all learning abilities. At its heart is a computer system that will access, search, and manipulate data from such sources as the JPL planetary images on CD-ROM. The CD-ROMs will be treated as very large databases, which PC-based program disks will manipulate according to four major educational emphases. First, teaching disks prepared by experienced educators will guide students (and teachers) through the data to give a basic education about the materials. Second, browsing disks will facilitate navigation of the databases using keyword, subject, or main idea indexing; students can record their "knowledge trail" through the data. Third, edit/test disks can be used by teachers. Fourth, creativity/edit disks will permit students to use the available information on the CD-ROMs in creative educational activities. A completed student "report," composed of hypermedia-like images, animation, text, and notes, could be saved as a real-time run program disk recorded on videotape; the data, images, and knowledge would become the tangible property of the student.

Potential Commercial Applications: Complete systems (i.e., hardware, software, CD-ROM players and interfaces) and the four information management disks could be marketed to school districts, libraries, and science museums.

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139 JPL
90-1-07.11-2732 NAS7-1129
Multi-Media Planetary HyperBook
Hypertech Systems
4497 Pinewood Road
Melbourne, FL 32934-9676
Madeline Kovarik (407-242-2732)

Placing the wealth of information available about the solar system, requires innovative applications of technology and alternative presentation approaches. This project focuses on the development of a multimedia HyperBook of solar system information. The HyperBook, as its name implies, uses hypertext and multimedia technologies to provide a flexible, interactive organization method to the information within the book. Merely providing an interactive, flexible interface does not, however, promote the exploration and assimilation of the information. Accordingly, students will be motivated to investigate and search out data through interactive games and role-playing software. Students act out adventures and roles which, to be successful, depend on knowing and understanding information within the HyperBook. The planetary provides, during the adventure, interactive access to information and,

through an embedded lesson plan, guidance to the adventure.

Potential Commercial Applications: This effort will greatly increase the effectiveness of student learning and retention by turning the student into an active participant in the learning process. The Hyperbook will be widely applicable to schools, corporate training programs, and NASA programs.

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08: Instrumentation and Sensors

140 GSFC
90-1-08.01-0003 NAS5-31385
An Iodine Standard Lamp
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Steven J. Davis (508-689-0003)

An innovative lamp source that could be an on-orbital standard for both wavelength and spectral responsivity calibrations of optical sensors will be built. The lamp will use well-characterized fluorescence from a molecular species (I_2). A unique feature of our approach is that the I_2 lamp will be excited by a stable light source that populates only a single quantum level in I_2. Because the emission characteristics of I_2 are so well known, this extremely selective excitation results in emission lines of fixed frequency and intensity over the entire wavelength range of 530 to 1340 nm. An analogous approach using an alternative lamp gas could extend this range into the ultra violet (225 to 450 nm). The primary objective of the Phase I program would be a laboratory demonstration of an optically pumped I_2 lamp as a calibration source for wavelength and radiometric response. Phase I results would be used to design a prototype, miniature lamp that would be constructed and tested in Phase II. This miniature standard would be valuable for any future missions that use sensors in the optical region.

*Potential Commercial Applications:*The optical source would have potential for manufacturers of optical sensors for space applications. A small lamp source that provided both wavelength and spectral response calibrations would also be extremely useful to any laboratory performing optical measurements. For example, the lamp could be incorporated into the commercial spectrophotometers found in most university and industrial laboratories.

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141 GSFC
90-1-08.01-0755 NAS5-31387
High-Power, High-Repetition-Rate, Diode-Pumped, Solid-State Laser Transmitter
Lightwave Electronics Corporation
1161 San Antonio Road
Mountain View, CA 94043
David C. Shannon (415-962-0755)

A high-power, efficient, robust laser transmitter, needed for topographic measurements from remote space platforms, is the goal of this project. This project describes the design, construction, and characterization of a prototype laser that will generate pulses of 1.047 μm light having energy greater than 1mJ at a repetition rate up to 1 KHz. The pulse length will be 10 ± 5 ns to provide a spatial resolution of approximately 3 meters as required by topographic measurements. A novel feature of this laser is that it will use one of the new 15-watt diode laser bars in an efficient, end pumped configuration. This feature will permit the laser to be very compact and easily scalable to higher powers as the diode laser bars continue to increase in output power. Also, this laser will employ an acousto-optic Q-switch that will allow repetition rates of greater than 50 kHz at reduced pulse energy.

Potential Commercial Applications: High-power, Q-switched lasers have applications in the areas of micromachining, printed-circuit-component trimming, and efficient harmonic generation for laser sources in the visible spectrum. The laser will also function as a roughly 3-watt CW source, as the 1-kHz repetition rate will require a CW pumping arrangement.

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142 GSFC
90-1-08.01-8315 NAS5-31386
A Millimeter-Wave Doppler Radar for Detection of Precipitation
Pulse Technology, Inc.
Box 306, 2652 South Main Street
Kennesaw, GA 30144
David S. Ladd (404-429-8315)

This project addresses the need for both satellite and supporting in-situ observation of precipitation rates and cloud-cover parameters. The goal is to design a fully productive, highly compact, millimeter-wavelength Doppler radar package for aircraft and ground-based operation that also has the potential for satellite application. Innovations will include a high-power, fully coherent radar transceiver operating in a dual polarization mode, as well as the the narrow beam widths of millimeter antennae in conjunction with pulse-compression techniques. Meteorological modeling and analysis will be done to guide the radar design to determine the optimum performance trade-offs between radar hardware capability and the radar reflectivity of the meteorological phenomena. The primary frequency of consideration will be 95 GHz, but other frequencies will also be investigated. In the Phase I research, the objectives of the scientific observations appropriate to a millimeter-wave Doppler radar will be defined and the Doppler radar system engineered to meet these objectives. Phase I will culminate in a report that details the scientific capabilities, total system and component design, and fabrication cost elements. This project will demonstrate the feasibility and scientific need for a developed, reliable, compact, and performance-documented millimeter radar instrument.

Potential Commercial Applications: Applications include weather radar with improved detection of snow, ice, and clouds; surveillance-type sensors that must provide high

resolution in fog; and shipboard or aircraft surface sensing requiring high spatial and temporal resolution.

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143 SSC
90-1-08.02-1419 NAS13-435
Neural Networks for Real-Time Data Evaluation in Remote-Sensing Instrumentation
Computer Applications Service
6207 Forest Trail
Signal Mountain, TN 37377
Craig Harston (615-886-1419)

To interpret, evaluate, and analyze data from remote-sensing, multispectral instrumentation in real or near-real time is the goal of this project. This system will be adaptive by learning to interpret application-specific features. Based on neural-network technology, it will focus on patterns found in the data regardless of the irrelevant variations of intensity, magnification, clutter, or noise. The system should be compatible with deployment in light aircraft or balloons for interdisciplinary research activities. In Phase I this project will design, develop, and test groups of interrelated neural networks to interpret data from different spectral bands. The interpretation of network-fused data from various spectral bands (0.4-14.0 micrometers) will be simulated as a proof-of-concept with a simple problem. Neural-network hardware will be reviewed to identify compatible electronics for the adaptive, real-time, multiple-network system recommended here.

Potential Commercial Applications: This real-time, multispectral, neural-network evaluation system should be useful for real-time, intelligent remote sensing; it should aid in the intelligent analysis and evaluation of agricultural, forestry, geographical, geobotanical, archaeological, or weather data.

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144 SSC
90-1-08.02-6078 NAS13-433
Portable Imaging Spectroradiometer for Ground-Truth and Earth Remote Sensing
Concept Development Associates (CDA)
1227 Ninth Street
Manhattan Beach, CA 90266-6017
Nahum Gat (213-376-6078)

A novel design for an imaging spectroradiometer for remote-sensing and ground-truth measurements is the goal of this project. Because no dispersion element will be used, the system will be small and lighter than common spectrometric systems by as much as a factor of 1,000; it will thus be particularly appropriate for airborne applications and portable use. A proprietary anamorphic optical system produces a rugged, permanently aligned spectroradiometer that provides a contiguous spectrum with a resolving power from several hundreds to several thousands. The device may be built either using a scanning system with a single element or line-array detector, or using a staring-area detector. Actual operating spectral resolution is controlled by software and may be changed in real time. Large area arrays provide the required spatial resolution down to 1 meter. The design is based on proven technologies, making this a low-risk, high-payoff development. Phase I includes the preparation of an operational-and performance-requirements list, the design of the spectroradiometer, and the preparation of a development plan for Phase II. Phase II will consist of a design verification and development breadboard device, followed by a prototype fabrication.

Potential Commercial Applications: Spaceborne and portable hand-held devices for industry and laboratory use are the main applications. In the military, the use in "smart munitions," IR missile seekers, and surveillance requires rugged, low-cost, small devices for which the concept is also suitable.

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145 LaRC
90-1-08.03-0490 NAS1-19284
An Airborne Particle-Imaging Nephelometer for Measuring Optical Phase Function
Spec, Inc.
450 Stratton Park Road
Bellvue, CO 80512
R. Paul Lawson (303-497-8941)

The optical properties of cirrus clouds remain a major unsolved component in cloud and climate research (Liou 1986). The current instrumentation available for in-situ measurement of the size, shape, and light-scattering properties of ice crystals is not capable of providing sufficient information to verify remote measurements (e.g., satellite, airborne lidar, and radiometers) of the optical and radiative properties of cirrus (Heymsfield et al. 1990, Wielicki et al. 1990). A new instrument capable of measuring the size, shape, and optical phase function of individual ice crystals in cirrus clouds is needed. In Phase I, theoretical calculations and proof-of-concept laboratory tests will be performed to verify the design of a particle-imaging nephelometer. The new instrument will image particles with 5-μm resolution and simultaneously measure the polarized and unpolarized components of scattered light in two 180° arcs around the sample volume. Phase II will see the building and testing of an airborne version of the instrument; it will also develop parameterizations and numerical simulations of the ensemble phase function of cirrus clouds.

Potential Commercial Applications: Applications to meteorological measurements in the field are numerous and include cloud and climate research, volcanic eruptions, forest fires, battlefields, and urban environments. The technology might also be used to measure particulates in the atmospheres of other planets and moons (e.g., the Triton Project).

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146 LaRC
90-1-08.03-6239 NAS1-19251
In-Situ Chemical Identification of Size-Segregated, High-Altitude Aerosol Particles
Femtometrics
1721 Whittier Avenue, Suite A
Costa Mesa, CA 92627
William D. Bowers (714-722-6239)

An important component in the study of atmospheric chemistry is the role of aerosol particles. These may be converted from gases, or act as reservoir or reaction sites for gases. Because most chemical analyses are performed in the laboratory following airborne collection, the integrity of the sample cannot be guaranteed due to changes in temperature and time delays prior to analysis. An innovative method of size-segregating aerosols in the upper atmosphere and collecting them on a highly sensitive, quartz-crystal microbalance—called the surface acoustic wave, quartz-crystal, microbalance cascade impactor (SQCM)—will be investigated. After the collection of the aerosols, selected target chemicals contained on them, such as HNO_3, HCl, and O_3, will be detected by reacting them with a selective reagent gas. Detection of gaseous chemicals will be obtained simultaneously, using chemically coated SAW crystals following the aerosol collector. Gas concentrations in the sub-to low-ppb range could be detected simultaneously with aerosols at a number density of 8×10^{-3} cm^{-3}, assuming a 0.3μm particle of density 1.6 g/cm^3.

Potential Commercial Applications: Highly sensitive chemical sensors that are small and inexpensive would be very useful in field monitoring of environmental waste sites or industrial settings.

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147 GSFC
90-1-08.04-1772 NAS5-31388
Laser Polarization Profiling
Intersonics, Inc.
3453 Commercial Avenue
Northbrook, IL 60062
Scott Hampton (708-272-1772)

The design, fabrication, and testing of a breadboard laser polarization profilometer (LPP) will be accomplished. The design uses a special polarization-preserving beamsplitter that delivers the reflected laser light to the detectors. A polarized, pulsed laser source is incorporated within the polarimeter package. The illuminated target and the laser spot are imaged by a video camera using an achromatic lens design. The pulsed, polarized, diode laser source is equipped with a remote control to permit spot size adjustment on the target. The light reaching the polarimeter is divided into three beams, two of which are orthogonally polarized, and one of which indicates the overall incident intensity. The light intensities are detected by PIN silicon photodiodes. The project objectives will include such design considerations as laser-power requirements for high signal-to-noise measurement and polarization sensitivity at a 300-m distance; the optical design of the achromatic system; laser spot detection and target viewing; and compact and rugged packaging of the mechanical system. At the end of Phase I, all of the optical and electronic interface requirements will have been defined, and a breadboard package will have been developed and tested simulating real conditions.

Potential Commercial Applications: Potential applications of the LPP technology include remote mapping of soil, vegetation, and geological features; scattering and polarization response; mapping; and surveying.

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148 GSFC
90-1-08.05-3088 NAS5-31389
Large-Aperture, Holographic Optical Elements for Scanning Telescopes
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Tin Aye (213-320-3088)

A novel, large-aperture, holographic optical element (HOE) for scanning telescopes will be developed based on volume Bragg holographic technology. The novelty lies in the fabrication of a multiple-narrow-bandwidth HOE that responds to wavelengths of 532 nm, 732 nm, 760 nm, 770 nm, 1.64 μm and 10.6 μm in a thin coating that does not require heavy optics and polishing. The objective of this project is to determine the appropriate HOE fabrication conditions for effectively producing narrow-band, multiwavelength-response, high-efficiency HOEs with large aperture, and to address the issues concerning their scalability, stability, optical performance, mass producibility, and commercialization. Recent advances and progress in high-resolution holographic recording materials and processing techniques have made it possible to fabricate high-diffraction-efficiency HOE using simple holographic recording methods. For example, a narrow-band HOE responding to 1.06 μm, 532 nm, and 355 nm can be fabricated using a single wavelength recording in a 20-μm, photosensitive polymer film, followed by wet and/or dry processing. Similar techniques can be applied for other wavelengths. Anticipated benefits of this research include reduction in weight and size of the telescope, improved performance, and extended life of the telescope.

Potential Commercial Applications: Applications of this technology include laser countermeasures, laser resonators, large space-based mirrors and solar windows.

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149 LaRC
90-1-08.06-0867 NAS1-19279
Narrow-band, Tunable Spectral Filters
Aurora Associates
3350 Scott Boulevard, Building 33
Santa Clara, CA 95054
I. C. Chang (408-748-0867)

A narrow-band spectral filter is a critical element in high-resolution lidars for atomsperic studies. Acousto-optic tunable filters (AOTF) offer the advantages of large optical throughput, rapid tuning over wide spectral range, and inherent modulation capability, and are therefore well suited to the lidar applications. The basic

deficiency of present AOTF technology is the limited spectral resolution achievable. Innovative approaches for resolution enhancement will be examined in the Phase I effort of this project, which includes a theoretical investigation of the new approaches and feasibility demonstration experiments for the selected optimum approach.

Potential Commercial Applications: Applications are for analytic instruments used in pollution monitoring, industrial control, and meteorological and medical areas. A near-term product would be a high-resolution spectrometer.

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150 LaRC
90-1-08.06-1910 NAS1-19266
Growth of Zinc Germanium Phosphide for OPO Applications
Inrad, Inc.
181 LeGrand Avenue
Northvale, NJ 07647
Warren Ruderman (201-767-1910)

An optical parametric oscillator (OPO) can provide high-power, infrared tunable over a broad range. The development of OPO devices has been limited by the scarcity of high-quality, non-linear crystals and low laser-damage threshold. $ZnGeP_2$ single crystals have an exceptionally high figure of merit (d^2/n^3, where d is the non-linear coefficient and n is the index of refractions that is approximately four times that of $AgGaSe_2$. A crystal growth process for $ZnGeP_2$ will be developed using a high-pressure Czochralski technique, rather than the sealed-crucible, Bridgman method used for $AgGaSe_2$. This process should produce higher-quality crystals with low absorption, high uniformity and good optical quality. The project includes the development of superpolished surfaces and high-damage-threshold AR coatings. Selected crystals will be characterized with respect to wavefront distortion, x-ray rocking curves surface roughness, absorption coefficient, and surface quality. Characterized crystals, polished and AR coated, will be delivered to NASA for evaluation as in OPO for the spectral region of 2.5 to 5.5 μm.

Potential Commercial Applications: A widely tunable IR laser source could have such uses as spectroscopy, atmospheric measurements of chemical species, lidar systems, doubling and quadrupling of 10.6 μm radiation, sum frequency mixing of 10.6 μm and 5-6 μm (CO laser), and for the detection of infrared radiation by upconversion using a pump such as Nd:YAG laser.

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151 LaRC
90-1-08.06-7528 NAS1-19283
High-Efficiency Frequency Doubler
Solidlite Corporation
15301 NE 90th Street
Redmond, WA 98052-3562
Larry G. Deshazer (206-869-4282)

This project will construct and deliver to NASA a highly efficient, second harmonic generator for 1.064 m fundamental laser radiation to meet the NASA requirement for efficient, non-linear frequency conversion at infrared wavelengths. The second harmonic generator has already been modeled as accurately as possible, using proprietary numerical computer codes that include the important effects of fundamental depletion, wavevector mismatch, angular and thermal dephasing, back-conversion of the generated 532-nm radiation, bulk absorption and Fresnel losses, and amplitude modulation of the input pulse. These methods offer a powerful capability for prediction and optimization of system performance, and point the way to the next generation of highly efficient harmonic converters. A frequency doubler with extraordinary conversion efficiency will be constructed for a 1.064 m fundamental laser, based on a design that has been optimized using the company's new codes. The frequency doubler will use precision optomechanical components, tested using a Nd:YAG laser to determine its performance characteristics, and then delivered to NASA.

Potential Commercial Applications: The availability of packaged, off-the-shelf highly efficient frequency converters will further extend the capabilities of non-linear optics to non-experts, and a wider market for non-linear optical materials will be found.

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152 MSFC
90-1-08.07-0204 NAS8-38893
Silicon Carbide Lightweight, 1-Meter-Class Mirror Development
SSG, Inc.
150 Bear Hill Road
Waltham, MA 02154
Leo R. Gardner (617-890-0204)

Silicon carbide (SiC) is emerging as a serious alternative for lightweight, spaceborne telescope applications as a result of commercially available, reaction-bonded fabrication techniques and replication-processing advances. SiC offers significant advantages: it has the lightweight features of beryllium, the cryogenic and optical performance and stability of glass, and the low cost of aluminum. This Phase I SBIR proposes fabricating mirrors by overcoating SiC subtrates with silicon (Si) to facilitate polishing. The similarity in thermal expansion between SiC and Si ensures an inherently athermal design. The specific tasks include the conceptual design of a 1-meter-class SiC/Si overcoat mirror and SiC mount assembly for visible-to-UV spaceborne applications, and the demonstration of this technology feasibility through the fabrication and testing of an 8-inch-aperture, concave, spherical mirror and mount assembly to near-diffraction-limited, visible-to-UV performance. Phase II would fabricate and test a prototype 1-meter-class SiC/Si mirror and mount assembly.

Potential Commercial Applications: A SiC/Si near-diffraction-limited, visible-to-UV telescope would be used for astronomical-, earth-, and atmospheric-science applications.

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153 JPL
90-1-08.08-5262 NAS7-1114
Cold Coronagraph for Planetary Observations
Sets Technology, Inc.
300 Kahelu Avenue, Suite 10
Mililani, HI 96789
Jonathan Gradie (808-625-5262)

The goal of this project is to produce an instrument for astronomical observations of solar system objects in the thermal infrared region (5-30μm), using an optical system that is capable of reconstructing an image (with movable apodizing masks) of electromagnetic radiation collected by a ground-based astronomical telescope. The opportunity is to apply techniques, previously used at visible wavelengths, in an infrared instrument that requires different optical materials and, most important, cold optics to utilize fully the high sensitivity of current state-of-the-art IR astronomical instrumentation. The objective of Phase I is to develop a detailed conceptual design that will show the feasibility of developing and testing an operating prototype instrument under Phase II.

Potential Commercial Applications: This technology could be applied in ground and spacecraft astrophysics; planetary science; terrestrial land, atmosphere, and ocean remote sensing; surveillance; geological mapping; forestry; land-use planning; and monitoring of industrial processes.

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154 GSFC
90-1-08.09-0774 NAS5-31421
XUV Image Detector Array
Princeton Scientific Instruments, Inc.
7 Deer Park Drive
Monmouth Junction, NJ 08852
J. L. Lowrance (201-274-0774)

In most current XUV image sensors, the photocathode is evaporated on the surface of a microchannel plate. However, the detective quantum efficiency of these devices is degraded by the microchannel plate surface and the attendant photoelectron ballistic path in reaching the channels, in comparison with photocathodes on smooth metal substrates. Such photocathodes in windowless image tubes have been successfully used in XUV astronomical observations, but their adoption has been restrained by the size and weight of the electromagnetic assembly employed to accelerate and focus the photoelectrons onto the anode. The proposed Phase I effort is to design a detector array suitable for use in spaceborne XUV sensors. In Phase II, a prototype will be built and evaluated. These XUV detectors would find application in academic and industrial research instruments.

Potential Commercial Applications: XUV spectroscopy is an active field of materials research in industrial and academic laboratories. Improved sensitivity of XUV image sensors would find a ready market.

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155 JPL
90-1-08.09-1929 NAS7-1122
Strained Type II Superlattice Infrared Detectors
Superior Vacuum Technology
7388 Washington Avenue
Eden Prairie, MN 55344
Peter Chow (612-941-1898)

This project will investigate the optical properties of a recently invented class of type-II, strained-layer superlattices made of GaAs related compounds. The new concept has advantages, compared with previous efforts, in that small band gaps may be achieved with sufficiently thin repeating layers in the superlattices. As a result, they have good optical-absorption properties and favorable electrical-transport properties. Original calculations have indicated that $Ga_{1-x}In_xSb/InAs$ is the best choice for such application. Very recently, it has been shown to have the highest absorption coefficient at 10μm wavelength compared with all other superlattice materials. Project objectives are to fabricate, according to theoretical models, optimized detector structures and to evaluate their infrared optical properties. These will be fabricated by molecular-beam epitaxy (MBE), according to structural parameters determined from theoretical modeling. The sample will be characterized optically and evaluated for infrared detection applications in the 2-17μm region.

Potential Commercial Applications: Strained-layer type II superlattices could be incorporated in infrared detectors and detector arrays used in space astronomy, physics and atmospheric studies as well as medical and industrial thermal-imaging applications.

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156 GSFC
90-1-08.09-2231 NAS5-31411
Capacitor Components for 2 K Detectors
Ceramphysics, Inc.
921 Eastwind Drive, Suite 110
Westerville, OH 43081
W. N. Lawless (614-882-2231)

This project will measure for the first time the dielectric properties of seven categories of ceramic materials at 2 K to develop capacitor components for detectors and detector arrays. All ceramic samples are in the form of multilayer capacitors or can be made in this form by conventional ceramic processing. The categories are $BaTiO_3$-$SrTiO_3$ ceramics; proprietary manufacturers' compositions; Cd-Pb-Nb-Ta oxide ceramics; Pb-Mg-Sc-Ta oxide ceramics; $SrTiO_3$ glass-ceramic; unusual spinel-based ceramics having very large specific heats at 2 K; and a superionic conductor. The dependence of the dielectric constants and loss tangents of the samples on temperature, frequency (up to 1 MHz), and electric field will be measured at 2 K, as will the ac conductivity. All samples are on hand at CeramPhysics or will be donated by certain manufacturers at no cost. The goal of the Phase I research is to identify the most favorable materials for specific capacitor applications in detector technologies. A Phase II program would involve fabricating these materials into improved, ceramic, multilayer capacitors for testing with detectors.

Potential Commercial Applications: Multilayer ceramic capacitors could be applied to detectors and detector arrays operating at 2 K.

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157 GSFC
90-1-08.09-3000 NAS5-31419
Detector Arrays from the Direct Deposition of Superconducting Films on Diamonds
Talandic Research Corporation
P.O. Box 9503
Azusa, CA 91702
James H. Goble Jr. (818-334-3000)

A method will be investigated for fabricating detector arrays of high-temperature superconducting (HTSC) thin films directly on diamond substrates. Diamond is used to exploit the potentially wide wavelength responsivity of these films through non-bolometric mechanisms. Lithographic techniques are described which will help compensate for the extreme thermophysical mismatch between diamond and these superconducting films.

Potential Commercial Applications: This work applies to wide wavelength response cameras, radiometric imaging, spectrophotometric dispersion simultaneous with spatial imaging, and new lithographic techniques for HTSC films.

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158 GSFC
90-1-08.09-5411A NAS5-31392
The Manufacture of High-Gain, Sheared MCPs Through an Innovative Boule Design
Detector Technology, Inc.
P.O. Box K-300
Brookfield, MA 01506
Thomas J. Loretz (508-867-5411)

A unique instrument now exists that can be used to fabricate monolithic, high-gain microchannel plates (MCPs) through the "shearing" approach. It will accommodate MCP blanks ranging in size from 20mm to 85mm diameter. By design, it will produce both "C" and "J" type profile geometries. Present research indicates that a custom blank is required with a matrix wall thickness substantially larger than those normally made. This will require the fabrication of a starting boule, with an innovative blend of glasses and geometry. The objective of this project is to procure custom 25mm-format MCP boule material from a commercial manufacturer, shear the blanks and fabricate high-gain, 15μm resolution devices. Final gain is determined by plate length-to-diameter (channel thickness to pore diameter) ratio. Ratios of 100:1 and 120:1 will be tried, in an effort to provide plates demonstrating usable gains in excess of 5×10^5, at bias voltages below 2500 VDC and strip currents below 20 μA.

Potential Commercial Applications: Applications exist in ion microscopy, surface science, and particle physics.

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159 GSFC
90-1-08.09-6000B NAS5-31381
Radiation Hardening of Charge-Coupled Devices
Spire Corporation
Patriots Park
Bedford, MA 01730
Edward A. Burke (617-275-6000)

Analytical methods to select and design radiation hard charge coupled devices (CCDs) for applications involving exposure to space radiations. CCDs are crucial to the success of many present and proposed NASA missions; the radiation environments they encounter are capable of disabling these critical components. The objective is to bring together in a single document a description of the methods required to make quantitative predictions of radiation response for a wide range of space radiation environments. This will include new information concerning the contribution of field-enhanced emission to the radiation-induced dark current in CCDs. Information on this mechanism has only recently become available. Field-enhanced emission is important because experiments have shown that energetic protons or neutrons can produce an unacceptable number of very large dark-current spikes in CCDs. Using published information, new calculations will be carried out to reduce the uncertainties associated with existing models. The results will be assembled in a handbook format for application to the prediction of CCD response in a wide range of space radiation environments.

Potential Commercial Applications: Applications include development of computer programs for predicting CCD response in different radiation environments and identification of new types of device designs, concepts and materials.

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160 JPL
90-1-08.09-6621 NAS7-1135
Low-Noise Infrared Detector Readout Arrays for 2 Kelvin
Amber Engineering, Inc.
5756 Thornwood Drive
Goleta, CA 93117
James T. Woolaway (805-683-6621)

Space based, low-background infrared measurements present stringent performance requirements on the infrared detector arrays and their associated readout multiplexer circuitry. Very-low-temperature cryogenics environments (2 Kelvin) are required by these systems to achieve detector performance levels. These cryogenics environments pose technical challenges on the readout multiplexer performance. Although significant performance improvements have been realized in low-noise, low-temperature readout multiplexers, substantial systems penalties must be paid in the use of elevated temperature stages to operate these devices. This effort will demonstrate that low-noise infrared detector array readout multiplexers can be achieved through the use of TRW's advanced cryogenic-Complementary Metal Oxide Semiconductor (cryo-CMOS) fabrication process.

Potential Commercial Applications: Uses would be in low-background infrared systems, such as those on the space infrared telescope family.

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161 JPL
90-1-08.09-9806 NAS7-1138
Fabrication of IR Detector Arrays on Silicon Substrates by Pulsed Laser Deposition
Advanced Fuel Research, Inc.
P.O. Box 380343
East Hartford, CT 06138-0343
David B. Fenner (203-528-9806)

Project objectives are advancing the fabrication and design technology of IR detectors from bulk HgCdTe to the emerging technology of thin films; making progress toward films on silicon wafers; and implementing the technique of pulsed laser deposition (PLD) for the fabrication of these heteroepitaxial-compound, semiconductor IR detectors. Present methods of material growth, from bulk processes to the various techniques for depositing epitaxial films, are all unsatisfactory in one way or another. Bulk methods produce the least uniform material and are labor intensive in detector fabrication, while epitaxial films are more uniform but require expensive equipment (for example, molecular beam epitaxy or metal-organic chemical vapor deposition). PLD is the method of choice for this proposed study, in that only single laser targets are needed for the growth of most compound-material films, atomic-scale layer resolution is possible, repaid throughput is possible, and only a marginal investment is required for establishing the growth facility.

Potential Commercial Applications: Thin-film epitaxial materials for IR detector devices may find markets in high-performance applications such as space-based astronomy, thermal imaging, and tracking systems.

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162 GSFC
90-1-08.10-2650 NAS5-31412
Buried Hetrostructure PbEuSeTe/PbSnTe Long-Wavelength Tunable Diode Lasers
Laser Photonics Analytics Division
25 Wiggins Avenue
Bedford, MA 01730
Ze'Ev Felt (617-275-2650)

The goal of this project is to use molecular beam epitaxy (MBE) of PbSnTe and PbEuSeTe on PbTe substrates to develop and fabricate buried heterostructure (BH) tunable single-mode diode lasers emitting in the 15μm to 28μm spectral region with operation temperature in excess of 20 K. The BH diode lasers should deliver single-mode output power in the range of 0.1-1.OmW. Threshold currents at 20 K and 80 K should not exceed 2 ma and 11 mA, respectively. Temperature tuning rates should be between 3 cm^{-1}/K to 4 cm^{-1}/K (a fixed Pb salt material property) and current tuning rate should be minimized to values below 1800 Mhz/mA, thus directly satisfying NASA requirements for local oscillators for heterodyne detection. These lasers should also exhibit longer mode tuning in the range of 1.5-4 cm^{-1} per mode, and high-temperature, continuous-wave (cw) operation in excess of 80 K. In Phase I of this program the cladding layer composition, the doping profile, and the active layer thickness for a diode laser emitting at 15μm will be determined. Two working devices satisfying the above conditions will be delivered for evaluation.

Potential Commercial Applications: Areas of application include non-invasive medical diagnostics, environmental/atmospheric monitoring, trace analysis of electronic-processing gases, plasma-etching diagnostics, and impurity analysis of Si and GaA1As wafers.

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163 JPL
90-1-08.11-0888 NAS7-1133
Homojunction Barrier Infrared Detectors
Microtronics Associates, Inc.
4516 Henry Street, Suite 403
Pittsburgh, PA 15213-3728
Darryl D. Coon (412-681-0888)

The project involves the development of a new class of infrared detectors that are called homojunction barrier detectors because the photodetection process involves excitation over such barriers. The detectors are particularly promising for focal-plane-array applications requiring a high degree of pixel-to-pixel uniformity in the long and very long wave IR regions, and at even longer wavelengths of interest in astronomy. Present versions of these detectors possess low quantum efficiency, a feature shared by other infrared detectors with high uniformity such as Schottky barrier detectors, which are useful in the short and medium wave IR regions. Under Phase II the low quantum efficiency of homojunction barrier detectors would be substantially remedied by the development of detectors with many layers, each layer containing a thin homojunction barrier. Such multilayered structures can be fabricated by modern epitaxial growth techniques. The boosting of quantum efficiency in this way has a proven parallel in the area of heterojunction, multiple-quantum-well infrared detectors. Low noise is expected, based on our measurements of dark currents less than 10^{-16} amperes at bias voltages of up to 5 volts on simple silicon homojunction devices. The longest wavelength detected to date is 200 microns, achieved by using a germanium homojunction device.

Potential Commercial Applications: Applications include strategic and tactical defense, earth resource survey systems, industrial processing, environmental monitoring, security systems, and infrared astronomy.

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164 ARC
90-1-08.11-4000A NAS2-13362
A High-Efficiency, Low-Vibration, Long-Life, Pulse-Tube Spacecraft Cryocooler Employing Flexural Bearings
Stirling Technology Company
2952 George Washington Way
Richland, WA 99352
Peter Riggle (509-375-4000)

This project will develop and test the prequalification model of a pulse-tube cryocooler using a dual-opposed compressor with flexural bearings. Objectives for the Cryoflex™ cryogenic cooler are high efficiency, low vibration, a 10- to 15-year lifespan, and a design that can qualify for space flight. High efficiency will be achieved through the optimization of system parameters using a validated numerical optimization method, careful selection and implementation of regenerator technology, optimized electric-motor design, and use of flexural bearings for high mechanical efficiency. Dual-opposed piston technology with gas clearance seals will provide a 10- to 15-year lifespan. Phase I will produce a demonstration and evaluation unit optimized around a successful existing flexural-bearing compressor. Phase II will produce a fully optimized single- or dual-stage PM.

Potential Commercial Applications: The technology could be used for NASA, military, and commercial flight, as well as in laboratory applications. Additional applications include cooling of medical sensors, emerging superconductivity technology, and gas liquefactions for laboratory use.

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165 MSFC
90-1-08.12-5262 NAS8-38905
Variable-Spatial-Resolution Infrared Spectrometer
Sets Technology, Inc.
300 Kahelu Avenue, Suite 10
Mililani, HI 96789
Jonathan Gradie (808-625-5262)

An instrument will be developed that allows high wavelength resolution and variable spatial (angular) resolution, yet maintains high spectrophotometric sensitivity. It will operate in the wavelength region of 1 to 5μm; have variable resolving powers, $\lambda/\Delta\lambda$ computer) between 500 and 4000; have an angular resolution of 0.5 to 3.0 arcseconds; be designed for an f/5.5, 6.5-meter astronomical telescope; and be computer controlled. The objective of Phase I is to develop a detailed conceptual design and show the feasibility of developing and testing a prototype instrument under Phase II. Most of the Phase I effort will be spent in the following areas: generating applicable scientific and technical specifications, developing reasonable concept definitions, and producing the concept documentation that will demonstrate the feasibility of the design.

Potential Commercial Applications: The variable-spatial-resolution concept may yield new applications in astrophysics; planetary science; terrestrial land, ocean, and atmosphere remote sensing; surveillance; and general chemical and mineralogical analysis.

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166 JPL
90-1-08.13-6000 NAS7-1143
Pyro-Electric Detectors Fabrication by Epitaxial CVD Growth on Silicon
Spire Corporation
Patriots Park
Bedford, MA 01730
Anton C. Greenwald (617-275-6000)

Non-cryogenic, infrared detector arrays suitable for operation between 10 and 16 microns can be fabricated from pyro-electric thin films, such as strontium-barium niobate. Detector sensitivity, however, is limited by film thickness. Sensitivity can be increased by decreasing film thickness, but manufacturing technology currently sets a limit below which thickness cannot be reduced. Metalorganic chemical vapor deposition (MOCVD) will be explored as a means of removing this restriction, making possible a new class of more sensitive, non-cryogenic, infrared detectors. The effort will capitalize on recent developments in thin-film superconductor technology to grow $(SrBa)Nb_2$ and related compounds. MOCVD-compatible barium and strontium precursors have been synthesized within the past year, and are now available in limited quantities. They will be used to deposit films on silicon and sapphire substrates, and the resulting films will be characterized with respect to composition, structure, and thermal and electrical properties.

Potential Commercial Applications: This approach to fabricating pyro-electric materials will lead directly to improved infrared detectors, and indirectly to new opto-electronic circuits that take advantage of the ferro-electric and piezo-electric properties of ceramic thin films.

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167 JPL
90-1-08.14-3686 NAS7-1115
Quasi-Optical, Solid-State Multiplier Sources to 3000 GHz
Innovative Research & Technology
843 Yale Street
Santa Monica, CA 90403
W. A. Peebles (213-828-3686)

This project seeks to develop innovative, quasi-optical, solid-state multiplier systems that, when pumped by existing solid-state sources, will generate output at frequencies up to 3000 GHz. CW output powers of ~1 watt are anticipated at frequencies < 100 GHz; output powers of 1 to 100mw are expected in the far-infrared (300-3000 GHz) spectral region. Arrays of non-linear diodes will be produced monolithically, thereby eliminating the power limitations associated with individual multiplier systems. A novel, quasi-optical ring cavity will be used to couple the pump and multiplied emission. The system operation has similarities to a laser and, therefore, results in automatic, phase-locked operation. The primary goals of Phase I will be to determine (through analysis and experiment) the optimum quasi-optical approach for the various desired frequency bands, and to evaluate, through computer modeling, the most desirable non-linear device, thereby establishing the desired fabrication parameters. Phase II would involve the detailed design, construction, and test of the most appropriate quasi-optical multiplier systems identified in Phase I.

Potential Commercial Applications: Compact, light-weight, moderate-power, millimeter-wave sources are needed in areas such as satellite communications, radar systems, and molecular spectroscopy. The application of such sources, for example, to active imaging of

concealed weapons at international airports and embassies represents a major commercial market.

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168 JPL
90-1-08.15-2292 NAS7-1120
Universal Helium Magnetometer for Space
Polatomic, Inc.
2201 Waterview Parkway, Suite 1712
Richardson, TX 75080
Robert E. Slocum (214-690-2292)

A novel helium magnetometer will be examined for observation of magnetic fields of planets and interplanetary space. The magnetometer employs a dual mode of operation, with a single, optically pumped helium sensor to observe the magnitude and direction of magnetic fields as great as 10^5nT. The instrument, called a the universal helium magnetometer (UHM), uses a vector helium magnetometer (VHM) mode to observe fields below 500nT. For fields greater than 500nT, a scalar helium magnetometer (SHM) mode of operation will be used. A novel optical technique incorporating a miniaturized tunable laser will be used to locate the position of the magnetic-field vector. The tunable laser permits single-line pumping that should achieve an accuracy of 1 part in 10^6 of the field magnitude. The UHM sensor will be similar to the current JPL VHM sensor in mass and size. Phase I will define the concept for the UHM instrument, the sensor configuration, and the electronic-module concepts for the low-field vector mode, high-field scalar mode, and magnetic vector positioning mode. This will establish the feasibility of the UHM approach and lead to design and fabrication of a breadboard UHM instrument in Phase II.

Potential Commercial Applications: This technology could be applied in magnetometers for geophysics and mineral/petroleum exploration; biomagnetic heart and brain monitors; antisubmarine warfare buoys, barriers, and airborne magnetic-field sensors; and ELF communications.

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169 ARC
90-1-08.16-6239 NAS2-13355
Continuous Real-Time Monitoring of Size and Mass of Particles Generated by Gas-Grain Conversion Processes
Femtometrics
1721 Whittier Avenue, Suite A
Costa Mesa, CA 92627
Raymond L. Chuan (714-722-6239)

An innovative, aerosol-particle sampling system will be developed to meet the stringent requirements of NASA's micro-gravity, particle-research experiments in the Gas-Grain Simulation Facility (GGSF). The system is especially suited to the Exobiology Flight Program's measurement requirements. By using inertial separation of aerosol particles into desired size groups, a process not influenced by gravity, and weighing the size-segregated particles by piezo-electric microbalance (which is also independent of gravity), this measuring device can monitor, in real time, the particle and gas-particle processes in 6 of 20 experiments in the GGSF. It is particularly useful for the experiment on prebiotic particle formation in a simulated Titan atmosphere, because the technique retains the measured particles for physico-chemical analysis.

Potential Commercial Applications: A miniaturized, automated, quartz-crystal-microbalance instrument would be useful in process control and in manufacturing that involves aerosols and particles.

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170 JPL
90-1-08.18-1500 NAS7-1140
An Active Fluorometer for Measuring Primary Productivity in the Ocean
G. Miller Machine Company, Inc.
1319 Pulaski Street
Riverhead, NY 11901-7817
Douglas J. Miller (516-369-1500)

An active fluorometer using a contained light source will be developed for rapid measurements of primary productivity of marine phytoplankton in situ. The fluorometer can be used as a water- profiling instrument on board ship, or as a self-contained device on moored or drifting buoys. The instrument will permit precise estimates of ocean primary productivity, better understanding of the environmental factors limiting carbon fixation in the ocean, and calibration of airborne/satellite color ocean sensors. The instrument will stimulate Photosystem II of marine phytoplankton in the absorption band of 410-490 nm by a series of flashes. Using high-energy, high-repetition-rate flashes, the phytoplankton fluorescence response, monitored at 685 nm, will be a function of the absorption cross-section of Photosystem II, the turnover time of photosynthetic apparatus, and the current photosynthetic rate under ambient irradiance. Several methods of generating the excitation signal will be investigated, such as xenon flashlamps, blue-light-emitting diodes (LEDs), or frequency-doubled, solid-state lasers. Based on a choice of the excitation source, a bench model of the fluorometer will be designed and tested. Successful completion of this project will lead to the development of a submersible version of the fluorometer and further efforts toward commercialization of the instrument.

Potential Commercial Applications: The fluorometer will measure primary productivity, characterize photosynthetic parameters of phytoplankton, and determine the nutrient/contamination status of a given body of water.

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171 GSFC
90-1-08.18-1512 NAS5-31413
A Multi-Band, Sea-Surface-Temperature, Infrared Radiometer
Ophir Corporation
3190 S. Wadsworth Boulevard, Suite 100
Lakewood, CO 80227
Loren D. Nelson (303-986-1512)

Recent research has shown the importance of calibrating and verifying satellite sea-surface-tempera-

ture (SST) radiometers using shipboard "skin" radiometric thermometers rather than buoy, in-situ thermometers. Since the satellite radiometers measure sea-surface skin brightness temperature, verification sensors should measure the identical skin temperature to achieve optimum satellite radiometer accuracy. Bulk and skin SSTs can differ by as much as 2°C, with the skin temperature typically 0.6°C cooler than the bulk temperature. A 5-band, ship-mounted, down-looking infrared radiometric calibrator will be devised to measure sea surface brightness-temperature to within 0.02°C. It is an evolutionary extension of an existing 4.25-3.7μm airborne radiometer. The SST radiometer will be used for sea truth calibration/verification of the existing and planned satellite sea-viewing radiometers. The radiometric calibrator is an improvement over current sensors in that it has very high (0.02°C) theoretical precision, achieves NBS intercomparison traceability in the field through a seawater bucket calibration standard and two internal blackbodies, and is designed to use 5 channels that match exactly the channel parameters of the planned moderate-resolution imaging spectrometer-nadir (MODIS-N) SST radiometer soon to fly on the EOS satellite.

Potential Commercial Applications: The shipboard radiometer could be used in fisheries research, to monitor global temperature increases, and to help predict hurricane paths by airborne monitoring of sea-temperature patterns.

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172 JPL
90-1-08.19-0867 NAS7-1125
Electronically Tuned Imaging Spectrometer with Variable Resolution
Aurora Associates
3350 Scott Boulevard, Building 33
Santa Clara, CA 95054
I. C. Chang (408-748-0867)

This high-performance, rapid-scanning imaging spectrometer uses an acousto-optic tunable filter (AOTF) as the wavelength tuning device. A risk-reduction effort will be conducted during Phase I. The tasks include developing innovative approaches to vary the spectral bandpass of the AOTF and carrying out theoretical and experimental research on the imaging characteristics of AOTFs. The results of the Phase I effort will be used for the design and construction of a high-performance imaging spectrometer in Phase II.

Potential Commercial Applications: Applications include industry process control (for example, thin-film monitoring and color separation), multicolor display, pollution monitoring, optical communication (wavelength multiplexing and covert communication), and medical instrumentation.

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173 JPL
90-1-08.19-1667 NAS7-1117
Efficient Production of All-Metal Cryogenic Telescopes
OCA Applied Optics, Inc.
7421 Orangewood Avenue
Garden Grove, CA 92641
Anthony B. Hull (714-895-1667)

This project focuses on the efficient production of the advanced optics typically used in orbiting spectrometers. Recent production technology allows efficient fabrication of all-metal telescopes and cameras. Micro-machining of optical surfaces and precision mounting points, low-stress plating, and new design methods and stabilization procedures are all factors. An all-metal telescope or camera may offer further advantages when the system is required to operate at reduced temperatures. If such a telescope assumes a different thermodynamic equilibrium, it may be expected to maintain focus and optical performance. The firm's metal optics technology (micro-machining, plating, design methods, and stabilization procedures) will be used to produce a telescope that will be suitable for subsequent cryogenic testing by JPL. Such a telescope would feature aluminum substrate optics and aluminum metric struts.

Potential Commercial Applications: The technology is applicable to a wide range of situations in which difficult aspheric optics must be fabricated economically and function over a broad range of temperatures.

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174 GSFC
90-1-08.19-3972 NAS5-31414
A Method of Producing Ultrasmooth, Precision Visible and X-Ray Mirror Blanks with Ultrastructured Materials
Multilayer Optics & X-Ray Technology Inc.
7070 University Station
Provo, UT 84602
Raymond T. Perkins (801-378-3972)

The approach in this project has the potential of producing aspheric mirrors with order-of-magnitude improvements in two key areas: first, in surface finish, figure, and lightness for small- and medium-sized (or mosaic) mirror blanks; and second, in the time and cost required to produce quality aspheric mirror blanks for large projects. The traditional sequence of grinding and polishing is reversed by the use of ultrastructure processing to replace mechanical methods of material removal. The method starts with a chemical-mechanical polished, flat silicon wafer of the type used in the semiconductor industry. The wafer is bent to the desired shape by the formation of stressed layers of silicon dioxode, silicon nitride, borophosphatesilicater glass, and so forth. The bending can be modulated to complex shapes by thinning the wafer in selected regions through anisotropic etching of the back of the wafer. The stressed layers, together with the etched pattern, precisely control the topology of the smooth surface. This method could be capable of controlling figure and smoothness on atomic dimensions. Phase I will show feasibility by measurement of the mechanical properties of the stressing layers, computer simulation of the

strongly interacting forces that control the surface topology, and precise measurement of surface topology.

Potential Commercial Applications: Applications include infrared, visible light, and X-ray beam handling; X-ray imaging (telescopes and microscopes); X-ray astronomy; X-ray microlithography (masks, beam handling, demagnification); X-ray analysis; and optical computing and processing.

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175 GSFC
90-1-08.19-7045 NAS5-31417
Optical Coatings for Infrared Detectors Using Pulsed RF Plasma Polymerizations
Polytronix, Inc.
805 Alpha Drive
Richardson, TX 75081
Jacob W. Lin (214-238-7045)

This project aims to devise a new approach to optical coatings for infrared detectors. Specifically, it centers on the use of a novel, pulsed RF plasma deposition process. With respect to optical coatings, the pulsed RF plasma technique has significant advantages over other coating methods, such as continuous-wave plasma and other CVD and conventional methods. These advantages include variation in the molecular composition of the film (with changes in duty cycle for a given monomer), better control of film thickness, and the ability to deposit optical-grade coatings while maintaining the substrate at temperatures below 45°C. The use of the pulsed RF plasma technique is especially well suited for the production of anti-reflective coatings for infrared detectors. The process described is especially promising for far infrared detectors. These films can provide improved protection for these detectors from environmental degradation, a benefit for low-earth-orbit materials subjected to oxygen atom attack. Although the technology described emphasizes optical coatings for infrared detectors, the control of film composition obtained with pulsed RF plasmas will be applicable to other materials.

Potential Commercial Applications: Applications include anti-reflective coatings for a vast array of electro-optic devices in communications and laboratory instrumentation, as well as for night-vision goggles. The technology should also be useful in applications such as thin-film, dielectric materials.

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176 MSFC
90-1-08.20-1040A NAS8-38919
Automated, Deterministic Asphere Fabrication
Sandia Systems, Inc.
13423 Desert Hills Ne
Albuquerque, NM 87111
Scott R. Wilson (505-294-1040)

In this project, ion-beam-figuring techniques will be applied to figure aspheric optical elements. A lens will be corrected for 5th-order aberrations as a demonstration. Simulated ion-beam figuring of more complex elements will be performed to illustrate the power of the technique.

Potential Commercial Applications: Ion-beam figuring is a deterministic figuring process that has wide-ranging application as an optical-processing technique.

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177 MSFC
90-1-08.20-1667 NAS8-38894
Aspheric Surface Figuring Using Plasma-Assisted Chemical Etching
OCA Applied Optics, Inc.
7421 Orangewood Avenue
Garden Grove, CA 92641
Steven J. Hoskins (714-895-1667)

This project should produce an automated method for the direct fabrication of finished, precision, aspheric surfaces on silicon optical elements, using a plasma-assisted chemical etching (PACE) process. This method would make possible the figuring of such surfaces, beginning with simple polished, spherical substrates in a single operation. The Phase I effort will focus on the selection of appropriate plasma parameters and fluorinated gas chemistries that produce a smooth surface etching while providing a smooth figure using the firm's automated aspherizing approach. Experiments will be conducted using silicon wafers to quantify removal rates, footprint contours, and surface roughness using candidate PACE configurations. These experiments will use an existing prototype PACE aspheric figuring system. The results of Phase I will define a plasma-etching configuration that can meet the requirements of the automated, one-step optical-figuring process.

Potential Commercial Applications: Applications would be in inexpensive aspheric silicon optical elements in systems that operate in the 3-5 micrometer infrared wavelength region.

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178 MSFC
90-1-08.20-6881A NAS8-38911
Generation of Large Optical Surfaces Through CNC Thermally Assisted, Ductile-Regime Grinding
Advanced Ceramics Research, Inc.
4541 E Fort Lowell Road Suite 211
Tucson, AZ 85712
Kevin L. Stuffle (602-323-6881)

Ductile chip formation, unlike the brittle chip formation typically observed in diamond grinding of ceramics, does not leave behind surface or subsurface microcracks. Accordingly, machine processes involving polishing can be eliminated from fabrication if material removal during grinding occurs through ductile chip formation. Ductile chip formation is essentially an extrusion process in which an instability is created and a chip is formed. However, this method of grinding requires high specific energy and can cause excessive machine vibrations, thus affecting the accuracy of surface generation. The innovation in this project is to improve ductile grinding of brittle materials by introducing a predetermined pattern of microcracks within the

intended depth of cut of the workpiece. This may be achieved by introducing a suitably pulsating thermal field immediately ahead of the grinding zone. The moduli of the ceramic material in the thermally induced microcracked layer will be considerably lower than that of the virgin material, and extruding the microcracked layer to produce a ductile chip will consume significantly less specific energy. Such a process will not require further polishing. Machine vibrations will be substantially reduced, and low specific energy will allow the use of SiC wheels, making the grinding process more economical.

Potential Commercial Applications: Applications are foreseen in the surface preparation of ceramic components without surface flaws, especially for parts that experience considerable stress at their surfaces.

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179 GSFC
90-1-08.21-2200 NAS5-31415
Environment for Spacecraft Contamination Assessment
Caroware, Inc.
P.O. Box 34150
Bethesda, MD 20827
Nancy J. Pugel (301-299-2200)

This effort is aimed at defining of a comprehensive expert system for the study, management, and analytical treatment of contamination-control technologies, including treatment and processing of flight-measurement data. The system will provide management support, flight data and historical data use, selection and performance of analytical steps, and contamination-program monitoring. The innovation will also integrate historical data with current programs, thereby providing a comprehensive support to contamination engineering. No currently available implementation provides such a level of engineering support, user control, and flexibility.

Potential Commercial Applications: This product could be of interest to such organizations as spacecraft developers, engineering companies, and clean-room technology companies.

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180 GSFC
90-1-08.22-3434 NAS5-31416
High-Spatial-Resolution E x B Magnetic-Field Probe
Berkeley Research Associates, Inc.
P.O. Box 241
Berkeley, CA 94701
Jeffry Golden (703-750-3434)

The goal of this project is to produce a novel, magnetic-field probe that has the potential to measure intense fields with high spatial resolution. This device comprises an electron-emitting electrode and an electron collector arranged in an E x B configuration: E is the electric-field vector, and B is the magnetic-field vector. The electric field is temporally varied, and electrons flow to the collector only when the applied potential is sufficient to overcome magnetic insulation by B. Monitoring the time or voltage when the current can flow is used to determine the magnetic field. The device should have fast temporal response (dc to 1 MHz). The dynamics of the electron flow will be studied and suitable geometries determined. The feasibility of a practical probe will be investigated by calculating the principal scaling laws and making estimates of the spatial resolution, sensitivity, precision, and dynamic range. Small-scale, table-top experiments will be performed to validate analytic and numerical models. Critical issues to be pursued in subsequent research will be identified.

Potential Commercial Applications: The device could have applications in the precision mapping and monitoring of magnetic fields in charged-particle instrumentation (for example, magnetic spectrometers), particle accelerators (for radiation processing, scientific research, and medical therapy), and precision magnets for industrial and medical use.

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181 GSFC
90-1-08.23-0760 NAS5-31399
Growth of Lead Carbonate Scintillator Crystals
Crystal Research
1441 Sunnyside Terrace
San Pedro, CA 90732
Paul J. Schichta (213-831-0760)

This project responds to a need for large-volume, high-density, high-Z scintillator crystals for anti-coincidence shielding of gamma-ray astronomy detectors. The combined requirements of high capture probability and ultrashort coincidence windows (decay times) closely resemble the requirements for positron emission tomography (PET) scintillators. A recent extensive survey at the Lawrence Berkeley Laboratory indicates that cerussite (naturally occurring $PbC0_3$) is the best material found to date for both applications. At present, no technique for the growth of large, pure $PbC0_3$ crystals has been developed. The project will explore three novel techniques and develop one for the commercial production of large, pure, optically perfect lead carbonate scintillator crystals.

Potential Commercial Applications: These crystals should be the material of choice for all coincidence and anti-coincidence scintillator applications, including the potentially extensive use of PET for diagnosis of cancer and Alzheimer's disease.

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182 JPL
90-1-08.24-6655 NAS7-1130
New Concepts for HgI_2-Scintillator, Gamma-Ray Spectroscopy
Xsirius, Inc.
4640 Admiralty Way, Suite 214
Marina Del Ray, CA 90292
Jan S. Iwanczyk (213-578-6655)

The innovation is a high-energy, gamma-ray spectrometer based on crystal scintillators optically coupled to unique, advanced HgI_2 photodetectors (in contrast to coupling the scintillators to the more conventional light

sensors, i.e., photomultiplier tubes. Advantages include greater ruggedness, improved (up to 2X) energy resolution, markedly smaller size and weight (not much in excess of the scintillator alone), reduced power, and insensitivity to magnetic-field perturbations. The objective of Phase I will be to build and/or test and evaluate three novel concepts relating to the gamma-ray spectrometer innovation. The first effort will focus on a new design concept for the HgI_2 photocell, including a novel, transparent entrance electrode and packaging suitable for space/vacuum applications. Next, the project will examine multiple HgI_2 detectors coupled to a scintillator for improved light collection and spectrometer performance. Then, the project will aim at developing a novel material that could be positioned between the scintillator and the photodetector to shift the wavelength to better match the spectral response of the photodetector and possibly amplify the light signal. Satisfactory completion of this work will verify the usefulness of the innovation and provide data leading to Phase II development and refinement.

Potential Commercial Applications: The special advantages of HgI_2 photosensors for gamma-ray scintillator detection systems make them ideal for use in instrumentation for high-energy physics research, health physics, personnel monitoring, medical research, and other applications.

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183 MSFC
90-1-08.25-1311 NAS8-33897
NASA Three-Dimensional, Underwater Positioning System
Marquest Group Incorporated
8 Otis Park Drive
Bourne, MA 02532
Tagore Somers (508-759-1311)

The development of a three-dimensional, underwater positioning system will be based on modifications of the 300KHz, sonic, high-accuracy positioning system (SHARPS) to operate at 1MHz in order to obtain the required resolution. The modifications will provide the precision required by NASA to detect targets at distances up to 75 feet, with a resolution of 0.063 inches. The 1-MHz, sonic-sensor system will provide accurate three-dimensional measurements for NASA during hardware development and testing at the neutral buoyancy simulator. The modified SHARPS transducer, combined with the modified SHARPS software, will provide accurate three-dimensional measurements to interface with and drive the NASA computer-controlled equipment. The new hardware and software modifications will undergo verification, validation, and development testing followed by an on-site demonstration of the 1-MHz SHARPS system at MSFC. During the on-site demonstration, a complete assessment of the MSFC system requirements will be determined for the Phase II efforts.

Potential Commercial Applications: The short-range, high-accuracy SHARPS will find application in precision control of underwater vehicles working around ship hulls, in restricted spaces, around piers, and in tanks. It will also be useful in the precision underwater surveying and scale-model testing required for the design of offshore structures.

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09: Spacecraft Systems and Subsystems

184 LaRC
90-1-09.01-1911 NAS1-19272
Adaptation of a Multichannel Structural Analyzer as an Integrated Controls-Structures Design and Analysis Tool
Zonic Corporation
25 Whitney Drive
Milford, OH 45150
Mark I. Schiefer (513-248-1911)

Methods of adapting a commercial multichannel structural analyzer to perform integration of controls-structures design and analysis are investigated in this project. The fundamental architecture of certain multichannel structural analyzers may be augmented with appropriate real-time, microcode functions. This will allow both control design researchers and structural dynamicists to use a single platform for developing test methods to implement controller designs and system identification. The findings will aid in the analysis and solution of problems associated with ground testing of large space structures, and ultimately contribute to improvements in the design of such structures and their control systems. The project will also solicit communication between the two technologies of controls and structures, and increase the sharing of test requirements. Phase I will determine the feasibility of such an adaptation and what, if any, modifications to hardware and software will be necessary to conduct an integrated demonstration on a NASA test structure during Phase II. Commercially available controls-design and -analysis software packages will be evaluated as the front-end design processor for the multichannel structural analyzer.

Potential Commercial Applications: The integration of a single platform for controls-structures design will provide NASA and numerous commercial large spacecraft designers with a lower-cost, higher-fidelity method for developing and testing control theory for large space structures.

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185 LaRC
90-1-09.01-9995 NAS1-19281
A Hybrid Analytical-Intelligent Approach to Fault-Tolerant Control of Large Space Structures
Automation Concepts & Systems, Inc.
2600 Collins Springs Drive
Smyrna, GA 30080
John W. Curtis (404-799-9995)

This project combines hybrid control-theoretic techniques and artificial intelligence (AI) for the design of fault-tolerant control strategies for large space structures. Available AI-based or purely control-theoretic

techniques for fault-tolerant control offer no unified methodology to integrate the diverse issues of system modeling, fault detection and isolation, fault propagation, system restructuring, and controller reconfiguration. This project capitalizes on structural features of the system. The fault-tolerant design procedure combines signal redundancy and fuzzy logic. When a fault is detected, causal or qualitative reasoning is used to model its propagation to adjacent subsystems. The system is then restructured by isolating faulty components. Finally, a structural control law that reconfigures the original system controller to meet the primary objective of guaranteed stability while the system is operating in a degraded mode. Algorithmic developments will be demonstrated, using the thermal control system of the Space Station's common module as the test bed.

Potential Commercial Applications: This project will introduce innovative methods to the fault-tolerant control of space vehicles and other complex processes. Software packages and controller-sensor-actuator configurations could be provided for a variety of applications.

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186 GSFC
90-1-09.03-7640 NAS5-31401
A Digital Processor for an Earth-Horizon-Sensor Attitude Control System
Ithaco, Inc.
P.O. Box 6437
Ithaca, NY 14851-6437
Vaughn H. Selby (607-272-7640)

This is a project leading to definition of a digital-processor system for small spacecraft. The first phase of the program will examine several small-satellite programs to determine a typical, small-satellite mission. Next, these requirements will be translated into specific requirements for an attitude-control system that will guide hardware and software decisions. Hardware questions such as interfaces, processor choices, and memory and speed requirements will be determined and result in a preliminary block diagram, as well as weight and power budget. The software requirements will be examined and recommendations for an operating system and a language will be made. A top-level software block diagram will be prepared.

Potential Commercial Applications: The digital processor could be sold to government and private spacecraft manufacturers that do not have or do not wish to use their own computers. The software will serve the same market as well as support host-computer applications.

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187 GSFC
90-1-09.04-2700 NAS5-31402
Colored-Noise Simulation and Characterization and Effects on Attitude Accuracy
General Sciences Corporation
6100 Chevy Chase Drive, Suite 200
Laurel, MD 20707
Stephen Bilanow (301-953-2700)

Standard techniques for the estimation of attitude-determination accuracy assume that the input sensor data has uncorrelated, white noise, and that simulators generally provide white noise. However, real sensor noise is generally observed to have more dominant lower-frequency components. Therefore, this project will develop software to simulate colored noise efficiently, test the noise characteristics, and estimate the impact of the noise characteristics on the predicted attitude-determination accuracy. This project will also explore efficient-noise characterization as a means of automatically identifying subtle anomalies in real data. This work is new and will add an important perspective in the understanding of obtainable attitude accuracies with realistic data. It will also provide tools for realistic data simulation, flight-data characterization, and anomaly identification. These tools will be developed on a PC.
Potential Commercial Applications: Practical analysis of obtainable attitude-determination accuracies would be of wide interest. Further, a commercial analysis tool based on this methodology could be applied to a wide range of error-analysis problems. The automated anomaly- identification techniques investigated could also find wide application.

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188 JSC
90-1-09.05-1010 NAS9-18460
Compact Lidar for Simultaneous Range and Velocity Measurements
Tacan Corporation
2330 Faraday Avenue
Carlsbad, CA 92008
Rainer K. Battig (619-438-1010)

A coherent lidar system for measuring the range and velocity of solid objects will be developed. The illumination and local oscillator beam are both derived from a frequency-modulated laser. For stationary targets, this causes a beat signal related to the range-induced time delay of the target scatter. For moving targets, the range-induced beat note appears at a Doppler-shifted position. An appropriate modulation format can decouple the effects of range and velocity; the method allows one to distinguish between receding and advancing targets. The compactness, alignment robustness, and sensitivity are enhanced by an innovative transceiver and mixer scheme based on fiber-optic waveguides. Fiber-optic components minimize space requirements and inherently guarantee high mixing efficiencies. A single-mode transmit and receive aperture optimally matches the receiving and transmitting directivities. A balanced mixer scheme liberates the system from laser excess noise, leading to shot-noise-limited detection at low frequencies. Estimates indicate excellent potential for measuring the range and radial velocity with a precision in excess of 1 percent and .003 m/sec, respectively.

Potential Commercial Applications: The benefits of the innovation are in the realms of motion control, flow measurements, and ranging.

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189 JSC
90-1-09.05-5649 NAS9-18467
Laboratory Demonstration of Innovative, Compact Three-Dimensional Imaging Sensor
Daedalus Enterprises, Inc.
P.O. Box 1869
Ann Arbor, MI 48106
Karl G. Wesolowicz (313-769-5649)

This project will experimentally determine the feasibility of obtaining a high-resolution, three-dimensional image of a scene using an innovative, focal-plane processor to produce a compact optical sensor. The innovation is in the gating of the image intensifier to demodulate an amplitude-modulated laser beam. This optical homodyne process uses focal-plane processing to acquire the three-dimensional scene. The advantages of this sensor over existing sensors will be reduced size and weight, reduced power consumption, and increased reliability. In addition, the sensor's range and reflectance imagery performance will be equal to or exceed current-generation sensors. This three-dimensional sensor can be used to enhance autonomous and tele-operated robotic applications for maintenance and satellite retrieval as well as space-vehicle rendezvous and docking. The effort will use five major components: an RF-modulated laser diode; an imaging lens; a gated-image intensifier; a CCD camera; and a data-acquisition system. This configuration will be used to obtain range imagery and to characterize fully the focal-plane signal processing, Fourier terms, and system effects from laser power, ambient light, standoff distance, and target reflectivity.

Potential Commercial Applications: A three-dimensional sensor could substitute for a two-dimensional video camera to improve performance in quality control, mensuration, robotic bin-picking, autonomous-guided-vehicles, and in maneuverability. A sensor of this type is also suitable for the use of tele-operated robotic manipulators for hazardous waste.

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190 JSC
90-1-09.05-8988A NAS9-18461
Log-Polar Binocular Vision System
Transitions Research Corporation
15 Great Pasture Road
Danbury, CT 06810
Carl F. R. Weiman (203-798-8988)

This project is addressing the design of a new binocular, stereo, robotic vision system that is three orders of magnitude more efficient and compact than current conventional systems. The new approach is based on log-polar coordinate, image-plane sensor arrays rather than conventional, Cartesian-coordinate-based arrays. Significant reductions in pixel count and computations per pixel result. The system will add passive, three-dimensional sensing capability to robotic vision systems for STS docking, planetary landing, EVA retrieval, Space Station construction, and the FTS. The dramatic improvement in compactness and energy consumption over alternative three-dimensional sensing methods is crucial for space-vehicle feasibility. Phase I will develop algorithms, test them on NASA imagery, and design laboratory prototype hardware to be constructed in Phase II.

Potential Commercial Applications: Applications include three-dimensional vision for manipulation, assembly, docking, and navigation.

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191 JSC
90-1-09.05-8988B NAS9-18489
Log-Hough Transform Feature Detector
Transitions Research Corporation
15 Great Pasture Road
Danbury, CT 06810
Carl F. R. Weiman (203-798-8988)

Prototype hardware will be designed for executing the log-Hough transform on imagery at video frame rates. This recently developed transform is three orders of magnitude more efficient than the traditional Cartesian Hough transform, and is a powerful technique for identifying robustly extended linear features despite the presence of gaps and noise. Examples range from Space-Station structural elements to orbital-debris tracks. Space applications include autonomous, visual-docking, and robotic constructions. Ground-support applications include high-speed, automatic recognition of orbital-debris tracks in star-field imagery. Preliminary feasibility studies indicate that orbital- debris processing can be achieved at rates of 33 ms per image by using hardware hosted in the backplane of a single IBM PC/AT- compatible computer. NASA has applied log-polar coordinate mapping in the design of efficient visual tracking and docking systems. The addition of the log-Hough transform to these systems extends their capabilities to much broader applications in robotic vision. Linear features are a cornerstone of pattern recognition, and the ability to recognize them quickly in compact hardware is a powerful attribute that will benefit robotic vision systems generally.

Potential Commercial Applications: Application could occur in robotic vision for manipulation, assembly, docking, navigation, and processing satellite imagery (e.g., road finding).

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192 JSC
90-1-09.06-1024 NAS9-18455
Surface-Discharge AC-Plasma, Color, Flat-Panel Display for Space-Station Applications
Photonics Imaging
6975 Wales Road
Northwood, OH 43619
Peter S. Friedman (419-666-1024)

Large-area, high-resolution, full-color, flat-panel displays are not currently available from any manufacturer. The aim of the project is to develop such a display, with both gray-scale and video capability, using a new AC-plasma memory panel structure. Plasma displays are the leading flat-panel color technology being developed in Japan for large-area, high-definition television, and there has been tremendous progress in these devices over the past few years. The primary

objective of Phase I is to demonstrate the feasibility and characteristics of the new AC-plasma structure and compare its performance with more conventional double-substrate, color-plasma panels currently under development. A surface-discharge panel structure appears to offer a number of important technical and manufacturing advantages over present plasma configurations. A minimum of 16 panels will be fabricated, with four critical parameters systematically varied. These panels will have a picture resolution of 128 x 128 cells. Phase II will optimize the panel structure to produce a 19-inch-diagonal, 640 x 480 pixel full-color display. This display will be delivered to NASA with dynamic drive electronics and demonstration software.

Potential Commercial Applications: The color, dot-matrix, flat-panel display has numerous applications, including laptop computers, workstations, high- definition television, avionics, medial imaging, CAD/CAM, military command and control, scientific instruments, navigation and communication systems, air-traffic control, radar and sonar systems, interactive educational systems, personnel training and simulators, and sensor monitors.

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193 JSC
90-1-09.06-9388 NAS9-18463
High-Efficiency Backlight for Color LCD Displays
Amerasia Technology, Inc.
2248 Townsgate Road
Westlake Village, CA 91361
Richard Ketchpel (805-495-9388)

Recently developed commercial laptop LCD terminals, using a powder, electro-luminescent backlight with a super-twist, LCD display surface, exhibit much-improved viewing contrast and battery life. The backlight system still consumes 90 percent of the power. In the case of color LCD displays, the backlight power consumption is even worse: as much as 96 percent of the battery power is wasted on the inefficiency of the backlight system. A high- efficiency backlight system, based on the use of thin-film electroluminescence (TFEL) color stripes as the light source, coupled with concentrating optics, could have a significant impact on battery life for a portable computer. In particular, the new color backlight design could result in a 10-fold increase in efficiency over the current design. Other features include minimum backlight thickness and excellent temperature stability. Phase I will establish the feasibility and compatibility of the various components required for this advance.

Potential Commercial Applications: The high-efficiency backlight will have immediate commercial application in existing color LCD, portable-computer terminals. In addition, the system will be useful for color LCD displays for avionic use.

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194 GSFC
90-1-09.07-7267 NAS5-31403
MMIC Circulator for Spacecraft Data-Transfer Applications
Hittite Microwave Corporation
21 Cabot Road
Woburn, MA 01801
Brian Bedard (617-933-7267)

To realize the full potential of the monolithic microwave integrated circuits (MMIC) technology, it is necessary to develop MMIC-compatible circuit technologies for non-reciprocal circuit functions. Based on demonstrated capabilities of active MMIC circulators operating in microwave frequencies, this project will extend design capabilities up to K- and Ka-band frequencies. Availability of MMIC circulators will lead to a higher scale of integration, with attendant size reduction, weight reduction, and reliability improvement for the total RF equipment. Phase I will establish the design approach and expected RF performance characteristics of K-band circulators and provide a baseline for product demonstration in Phase II.

Potential Commercial Applications: Applications include microwave communications, microwave sensing and ranging, and instrumentation.

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195 JPL
90-1-09.09-4900 NAS7-1121
Using Pressed and Sintered Bi-Sb to Improve Thermoelectric Coolers Below 200K
Marlow Industries, Inc.
101451 Vista Park Road
Dallas, TX 75238-1645
Edward H. Volckmann (214-340-4900)

This project lays the foundation for the development of a practical thermoelectric cooler that will obtain colder temperatures than 160K and/or higher efficiencies than current coolers when operating below 200K. The improved thermoelectric cooler would use N-type Bi-Sb, produced through powder metallurgy, in the stages operating below 220K. This work would be a departure from traditional Bi-Sb research, which has concentrated on the production of single-crystal materials. Phase I will demonstrate the feasibility of developing N-type Bi-Sb through powder metallurgy, which offers myriad advantages over conventional, single-crystal Bi-Sb. Bi-Sb that is developed through powder metallurgy is easier to produce, dimension, and handle than single crystal Bi-Sb. The fine-grained microstructure produced by powder metallurgy also eliminates the danger of catastrophic failure due to cleavage, a serious problem with single-crystal Bi-Sb. When successfully produced, N-type Bi-Sb will be incorporated into thermoelectric coolers, resulting in lower operating temperature capabilities and higher efficiencies.

Potential Commercial Applications: High-performance, thermoelectric coolers could be used in medical instruments, night-vision systems for commercial security and law enforcement, thermal-detection devices for quality-

inspection techniques, and eventually in cooling superconductors.

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196 JPL
90-1-09.09-6352 NAS7-1136
Cryogenic Refrigeration Systems
Analytic Power Corporation
P.O. Box 1189
Boston, MA 02117
David P. Bloomfield (617-542-6352)

A new approach to closed-cycle, cryogenic cooling will be developed using a polymer-membrane-based, electrochemically driven cryostat that employs oxygen as the two-phase working fluid in a modified Linde-Hampson, double-expansion cycle. The cycle permits the use of advanced membranes in an electrochemical compressor. Improvements in size and cost by a factor least two, with no increase in coefficient of performance, are projected. Like other electrochemical compressors, this electrochemical cryostat has no moving parts. Phase I addresses the feasibility issues surrounding the cryostat with an experimental investigation of both anionic and cationic cell performance. An approach to water management for the cryostat will be analytically investigated.

Potential Commercial Applications: This approach will permit the replacement of conventional, mechanically driven, compressor-cryogenic systems with electrochemical units. Cost and operational advantages are expected.

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197 GSFC
90-1-09.10-2231 NAS5-31420
Improved Regenerator Materials for Cryocoolers
Ceramphysics, Inc.
921 Eastwind Drive, Suite 110
Westerville, OH 43081
W. N. Lawless (614-822-2231)

Japanese researchers have recently developed Er-based alloys that have large specific heats below 15K, and have demonstrated improved regenerator performance using these materials. These alloys, however, are very expensive and brittle. This project focuses on inexpensive ceramics that have much larger (peak) specific heats than the Er-based alloys. In an effort to overcome their low thermal conductivities, these ceramics they will be loaded in powder form into cesium and thallous halides that have metallic-like thermal conductivities. An additional benefit of this composite approach is that the grain size of the ceramic powder broadens the specific heat peak. The positions of the specific heat peaks can be temperature-shifted by doping, and one Fe-doped case will be investigated. (A substantial database exists on these ceramics from previous Air Force programs aimed at other applications, including a variety of dopant effects.) In Phase I, a matrix of composite samples will be made with powder-grain sizes of 0.02, 0.2, and 2.0 μm, and the thermal properties of these composites will be measured from 4.2 to 15K. The hardness of these composites will also be measured, and specific composites will be recommended for a Phase II program aimed at regenerator and cryocooler testings.

Potential Commercial Applications: This project applies to improved regenerative-cycle cryocooling for space applications, cryopumps, cooling of MRI magnet shields, etc.

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198 GSFC
90-1-09.10-3200 NAS5-31398
Small Liquid Pump for Space Thermal Systems
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Andrew C. Harvey (617-890-3200)

Small liquid pumps capable of operating with very low suction pressure could be used on satellites and space platforms: for ammonia thermal buses, enhancement of heat pipe radiators, and internal (habitable) thermal control using water. A tiny rotary pump capable of several cm^3/s flow suitable for a 2-kw thermal load with ammonia will be demonstrated. It will be designed and tested for very low suction-specific speed. Phase II should be refinement of design and life testing.

Potential Commercial Applications: As commercial satellites become larger, they will require more complex thermal buses and deployed radiators to optimize the overall design. Availability of good micropumps will permit improved system performance and economy.

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199 GSFC
90-1-09.10-8177 NAS5-31418
Spacecraft Thermal Management Using Metal-Matrix Composite
Composite Applications & Procedures
641 Weller Court
Simi Valley, CA 93065
Albin M. Nowitzky (805-584-8177)

The thermal conductivity of graphite-aluminum metal-matrix composite (MMC) has been shown to be significantly greater than that of unreinforced aluminum. Related investigations have further demonstrated that substitution of graphite-aluminum MMC for aluminum in space-based radiators can improve thermal transfer by more than 25 percent, as well as reduce radiator weight. Continued analysis implies that, by substituting copper-matrix MMC for aluminum-matrix MMC, a substantially greater heat transfer rate is attainable with only a modest increase in radiator weight. Improvements in heat transfer result from higher thermal conductivity plus the elevation of radiator operating temperature. Other benefits are derived from the low, tailorable coefficient of thermal expansion (CTE) of the MMC. The primary objective of Phase I is to establish how graphite-copper can improve spacecraft thermal management, and to show the extent of this improvement when compared with either aluminum or copper alone.

Potential Commercial Applications: Applications would be in space installations with high-power requirements: communication satellites, inhabited space stations, and lunar and planetary bases.

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200 JSC
90-1-09.11-0851A NAS9-18456
High-Temperature, Waste-Heat-Driven Cooling Using Complex-Compound Sorption Media
Rocky Research
P.O. Box 1086
Boulder City, NV 89005
Lance D. Kirol (702-293-0851)

Manned lunar bases will require cooling for dehumidification (about 40°F) and habitat (60°F). The background temperature for heat rejection is 125°F, requiring reject temperatures of 180°F or above. Waste heat will be available from the power-generating system above 500K (440°F). Complex-compound sorption cycles can be used to provide cooling and heat rejection at these temperatures, and can be driven with waste heat near 500K. Waste-heat-driven cooling cycles will reduce the load on the power- generation system while reducing total heat rejection. Complex-compound cycles are potentially ideal for this application because they provide high temperature lift, are reliable (having no moving parts), and are light. Efficiency can approach 80 percent of the Carnot limit. The objectives of Phase I are to prove the concept in the laboratory and provide estimates of mass and efficiency of an optimized system. The objective of Phase II will be to demonstrate a cooling system optimized for lunar conditions and provide more accurate mass and performance projections. Phase I efforts will be directed toward a small-scale (up to about 100- W cooling) laboratory demonstration and computer modeling of a full-scale heat pump.

Potential Commercial Applications: The temperature range involved--heat recovery at 60°F with rejection at 190°F--fills a need in industrial heat pumps for recovery of low-level waste heat and generation of high-temperature hot water. Such applications are prevalent in brewing and food-processing industries.

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201 JSC
90-1-09.11-3550 NAS9-18471
Nontoxic Heat Transport Fluids for Habitat Two-Phase Thermal Control Systems
Mainstream Engineering Corporation
200 Yellow Place
Rockledge, FL 32955
Lawrence R. Grzyll (407-631-3550)

This Phase I project will determine the feasibility of using a computational chemistry database system for the development of a nontoxic, two-phase, heat transport fluid for spacecraft thermal control systems. Experimental data on the physical and chemical properties of as many compounds as possible will be added to the database. A computational chemistry database system will then be used to predict molecules with improved properties over previous fluids. The properties of the improved fluids will then be determined and compared with the prediction. The properties of the improved compounds will be added to the database, expanding and improving it. Thus, the foundation for Phase II will be laid by determining the feasibility of this working-fluid development method. Phase II will continue the iterative process started in Phase I until the suitable fluid is developed.

Potential Commercial Applications: This project could have applications in the commercial air-conditioning industry.

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202 JSC
90-1-09.11-3800A NAS9-18480
High-Capacity, Heat-Pipe Radiator
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Javier A. Valenzuela (603-643-3800)

The heat rejection requirements of future space systems are projected to increase by an order of magnitude over the coming decades, to meet the needs of manned planetary missions and bases. The Space Station Freedom alone will require 75 kw of heat rejection at Assembly Complete (AC) and three to four times that capacity in the growth phase. The Space Constructable Radiators (SCRs) represent the major weight component in the thermal- management system, contributing about 40 kg/kw of heat-rejection capacity. The SCRs also represent the largest components, with a stowed volume of 0.16 m^3/kw. Using present technology, the growth phase of the Space Station Freedom will require transportation to space of 4,000 to 9,000 kilograms of radiator panels at a cost of about $40 to $90 million. This project addresses the development of a novel high-capacity, heat-pipe radiator that has the potential to reduce the radiator weight by a factor of 6 and the stowed volume by a factor of 10. The proposed radiator would have a specific mass of about 0.7 kg/m^2, which translates to about 6 kg/kw for heat rejection at room temperature in near-earth orbit. The radiator heat pipe is also inherently resistant to depriming, and its evaporator would have a significantly higher heat-flux capability than present designs. In Phase I, the feasibility of the concept will be demonstrated by designing the key elements of the radiator and performing some proof-of-concept tests.

Potential Commercial Applications: High-capacity, heat-pipe technology would have commercial application in the thermal management of communication satellites and in the cooling of high-power electronic systems.

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203 MSFC
90-1-09.12-5911 NAS8-38915
Solid-Solid, Phase-Change Materials for Low-Temperature Applications
Cape Cod Research, Inc.
P.O. Box 600
Buzzards Bay, MA 02532
Brian G. Dixon (508-759-5911)

This project will investigate polymeric composition that is specifically designed for low temperature (-50°F to -150°F) applications of all kinds. The new material promises to be capable of reversibly storing significant quantities of thermal energy using only solid-solid phase transitions. It will also be possible to adjust the temperature of the phase transitions, as well as the thermal storage capacity. The novel composition will be chemically inert and extremely stable to thermal stresses of all kinds.

Potential Commercial Applications: PCM materials could be used in storing samples at low temperatures for the medical, chemical, biological, and botanical fields.

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204 MSFC
90-1-09.12-7000 NAS8-38898
Transient Model of Cryogenic-Bearing, Thermo-Mechanical Operating Characteristics
SRS Technologies
990 Explorer Boulevard NW
Huntsville, AL 35806
David E. Marty (205-895-7018)

Cryogenic, liquid-propulsion systems for manned spacecraft use high-performance turbopumps with rolling-element bearings to support the turbine and pump shaft. These bearings operate at high speed in the cryogen being pumped; they are highly loaded and poorly lubricated. The resulting sensitivity to thermo-mechanical interactions can cause rapid loss of operating clearance, increases in heat generation and component temperatures, and rapid build-up of contact stresses. The result can be premature bearing deterioration or failure. Although some codes simulate steady-state conditions for these systems, the start, shut-down, and power transients are beyond their scope. This project will investigate and define modeling techniques to simulate the thermo-mechanical, transient characteristics of turbopump, bearing systems operating in cryogenics. The feasibility of developing and installing the simulation on a personal workstation will be investigated. The software package will be designed to augment current models of turbopump, shaft-bearing systems. Given the initial conditions, a description of the speed transient (including loads and coolant flow), and the geometrical characteristics, the model will predict the transient component temperatures and operating characteristics such as operating clearances, contact angles, stresses, and load distributions. This information is very useful in design evaluations, life assessments, and investigations of failure scenarios.

Potential Commercial Applications: Models for predicting the thermo-mechanical, transient characteristics of high-speed bearing systems operating in cryogenics could be modified for application to bearing systems in commercial superchargers and turbochargers, or in other high-speed rotating machinery that uses rolling-element bearings.

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205 MSFC
90-1-09.12-8122 NAS8-38888
SINDA/TRASYS Thermal-Model Development Tool Using Interactive Color Graphics
Huntsville Sciences Corporation
3315 Bob Wallace Avenue, Suite 107
Huntsville, AL 35805
James C. McAnally (205-568-8122)

This project will develop a non-proprietary, non-licensed, thermal-model development tool that is innovative in its simplicity and in its ability to create interactively SINDA and TRASYS models directly. The innovation will allow the user to graphically construct geometry models for both codes in an interactive mode, then these models for completeness and accuracy from different perspectives, through rotation and tumbling animation. When satisfied that the model is correct, the user will press a command key that instructs the graphics software to output automatically a file that will be used to construct a computational grid network of the model. The grid network will be displayed visually on the screen. Grid point packing and clustering can be performed and the results viewed in real time using grid cluster controls from pre-programmed keystrokes or "mouse-driven" graphical software controls. When satisfied with the nodal spacing, the user gives another keystroke command, which instructs the program to compute the input data set in the proper format for SINDA and TRASYS applications. These data include node volumes, surface area of the nodes, internal conductances, and thermal model. Using the thermal-environment data file, which includes both the radiation environment from TRASYS and the convective environment from MINIVER or a comparable heating program, the interface routine computes the external surface convection coefficients and surface radiation conductances that drive the SINDA thermal model.

Potential Commercial Applications: This tool could be applied by firms currently using SINDA and TRASYS to design thermal-control systems such as NASA and DOD contractors working on major programs.

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206 MSFC
90-1-09.13-3800 NAS8-38921
Cryogenic-Fluid Management for Spacecraft
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Paul H. Rothe (603-643-3800)

This project, in Phase I, will develop theory and define the requirements of engineering software and an engineering manual for the more challenging design aspects of cryogenic-fluid management systems. Particular attention will be given to fluid- and thermal-

management issues, given that the underlying scientific understanding of them is in a state of rapid evolution.

Potential Commercial Applications: This project will focus on immediate NASA needs for spacecraft development. Commercial benefits will result from improved means to handle cryogens.

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10: Space Power

207 LeRC
90-1-10.01-0540 NAS3-26232
Flywheel Energy Storage for Electromechanical Actuation Systems
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Richard L. Hockney (617-661-0540)

The innovation in this project is a flywheel energy-storage system designed specifically to provide load leveling in an advanced launch system (ALS) employing electromechanical actuators (EMA). One of the major advantages of an EMA system is that it significantly reduces the total energy consumed during a launch profile. To achieve this energy reduction, however, a localized energy storage must be devised that is capable of delivering the peak power required by the EMAs. A combined flywheel-motor-generator unit that interfaces directly with the 20-kHz power bus represents an ideal candidate for this load leveling. The overall objective of this project is to define a flywheel energy-storage system for this application. To accomplish this overall objective, the project will have four specific technical objectives: definition of the specifications for the flywheel-motor-generator system, including system-level trade-off analysis; design of the flywheel rotor; design or selection of the electromechanical system components including the motor-generator and bearings; and preliminary reliability, safety, and failure modes and effects analyses for the baseline system.

Potential Commercial Application: A system demonstration will show that flywheel technology is viable for energy storage systems. Individual component technologies, such as the motor-generator, will also be applicable to other power-systems applications.

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208 LeRC
90-1-10.01-4427 NAS3-26233
Lightweight, Flexible, Thin Film Solar Cells for Space Applications
International Solar Electric Technology
8635 Aviation Boulevard
Inglewood, CA 90301
Bulent M. Basol (213-216-4427)

The ever-increasing power demands of space missions require development of high-efficiency solar cells and modules with high specific power and good stability. Thin-film devices that can be economically fabricated on lightweight substrates are of great interest for these applications. This project aims to develop high efficiency, thin-film $CuInSe_2$ (CIS) solar cells. Both flexible-foil and thin-glass substrates will be used in this work, and 1 cm^2 cells with 9 percent AMO efficiencies will be fabricated using the two-stage process (selenization of Cu/In metallic layers). CIS thin-film solar cells offer the potential for 16 percent efficiency, and these devices have already been shown to be superior to Si cells in terms of their radiation resistance.

Potential Commercial Application: Cost-effective lightweight solar photovoltaic power systems in military and civilian space applications are urgently needed.

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209 LeRC
90-1-10.01-8888 NAS3-26136
A Robust, Manufacturable Alternator and Suspension for Free-Piston Stirling Engines
Clever Fellows Innovation Consortium Inc
R.D. 1 Box 410
Melrose, NY 12121
George Yarr (518-885-4156)

This project investigates a compound, flexure suspension and spin-prohibited alternator geometry for free-piston, Stirling-engine power conversion. The system appears to offer major improvements in reliability, mass and size, and manufacturing cost. The project will provide a design and life test for the suspension system and a complete conceptual-preliminary design of the associated alternator. Currently, bearings are the most unreliable components and alternators the most massive in a free-piston machine. Improvements in both reliability and power-to-mass are required to succeed with Stirling spacepower units. Cost and reliability improvements are required for terrestrial commercialization.

Potential Commercial Application: These innovations would eliminate the most unreliable components of free-piston, Stirling-engine power conversion systems, offering major advances for their space and terrestrial applications.

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210 GSFC
90-1-10.02-6700 NAS5-30565
Improved Solar Cell Cover-Glasses Coated by Low-Pressure, Chemical Vapor Deposition
Deposition Sciences, Inc.
386 Tesconi Court
Santa Rosa, CA 95401
Donald Z. Rogers (707-573-6700)

Improved optical coatings for solar cell covers that reject both infrared and ultraviolet radiation will be developed by using advanced design concepts and low-pressure, chemical vapor deposition (LPCVD) technology. Advanced thin-film design software will be used to simulate three material designs using thin layers of two materials. These designs will provide rejection in the ultraviolet and infrared, as well as improved transmission in the response band. A computer-controlled,

automated, LPCVD system that is capable of reliably coating such thin-layer optical designs will be used for deposition. The LPCVD system has the additional advantage of allowing stress balancing for thin substrates by coating both sides simultaneously, and has the potential for low-cost manufacture.

Potential Commercial Application: The work will be directly applicable to all commercial space systems that use solar power.

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211 JPL
90-1-10.03-2113 NAS7-1137
AMTEC Condenser Design for Zero-G Operation
Advanced Modular Power Systems, Inc.
4667 Freedom Drive
Ann Arbor, MI 48108
Thomas K. Hunt (313-677-2113)

Adequate electrical power for spacecraft operations is a crucial mission task. The isotope heat sources used in radio-isotope-thermoelectric-generators for many NASA missions are expensive. For a given electrical power, thermal-to-electric conversion with AMTEC rather than conventional thermoelectric converters should permit reduction of the GPHS complement by a factor of 3. The estimated cost savings may approach $40,000 per electric watt launched. AMTEC operates with metallic sodium as the working fluid and, up to now, all high-temperature, recirculating AMTEC systems have used gravity to carry the sodium from the condenser wall to a sump, where an electromagnetic pump returns it to the high-temperature zone. In zero gravity, with a conventional condenser, this approach fails because the sodium distributes itself on the condenser walls and fails to reach the pump inlet. For AMTEC space operation, other means of sodium control and circulation must, therefore, be developed. The approach in this project uses a wick structure to collect the sodium continuously at the condenser and deliver it to the inlet of an electromagnetic pump. The pump then returns the sodium to the high-temperature zone.

Potential Commercial Applications: The high efficiency of AMTEC conversion suggests that it may be useful for many terrestrial remote power applications, e.g., field portable and mobile systems, steered solar concentrators, air or ground vehicles, and navigation buoys.

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212 LaRC
90-1-10.04-6000 NAS1-19258
1.3 Micron In(AlGa)As Photovoltaic Laser-Energy Converters
Spire Corporation
Patriots Park
Bedford, MA 01730
Steven J. Wojtczuk (617-275-6000)

This project will investigate unique laser-energy converters (LECs) for 1.315 micron (0.943 eV) iodine laser, space power systems. The goal is to convert 40-50 percent of the incident laser power of 500-1000 W/cm^2 to electrical power. To achieve the optimum 0.94 eV bandgap, metalorganic chemical vapor deposition (MOCVD) of an innovative compound semiconductor, $In_{0.53}(Al_xGa_{1-x})_{0.47}As$, lattice-matched to InP substrates, is planned. The bandgap of $In_{0.53}GA_{0.47}As$ (0.75 eV), lattice-matched to InP, is suboptimal; however, by adding Al to the InGaAs so that the Al_xGa_{1-x} fraction stays at 0.47, the lattice match to InP is maintained at the same time as the epilayer bandgap increases. Initial calculations indicate $In_{0.53}Al_{0.13}Ga_{0.34}As$ has the optimum 0.94 eV bandgap. An innovative, planar, series-connected, multijunction LEC should limit series resistance effects. A planar approach avoids some of the processing problems inherent in vertical multijunction designs. In Phase I, $In_{0.53}GA_{0.47}As$ (control) and $In_{0.53}Al_{0.13}Ga_{0.34}As$ prototype layers will be grown on InP substrates with InP windows. The bandgaps will be checked by photoluminescence, the lattice match by X-ray diffractometry, and the doping by CV profiling. Cells will be fabricated to check the pn junctions and to measure the log IV, quantum efficiency, and power-conversion efficiency. Planar, multijunction LEC will be designed using measured data from the actual material, with particular attention paid to attaining a low series resistance and high efficiency. In Phase II, full-sized, optimized, planar, series-connected multijunction LECs based on the Phase I work would be grown, fabricated, and tested.

Potential Commercial Applications: There may be a large market for custom epilayers in the $In_{0.53}Al_xGa_{1-x}As$ system for lattice-matched, opto-electronic applications requiring bandgap engineering from 0.8 to 1.4 eV, complementing the 1.4-to-2.3 eV range covered by the lattice-matched $Al_xGa_{1-x}As$/GaAs system.

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213 LeRC
90-1-10.05-0003A NAS3-26236
Electrocatalysts for High-Efficiency, Solid-Polymer-Electrolyte Fuel Cell
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
E. Jennings Taylor (508-689-0003)

A novel platinum catalyst preparation technique will be applied to develop electrodes for solid-polymer-electrolyte fuel cells (SPEFC). Previous work has shown that this novel technique results in high utilization of platinum. With this technique, low-platinum-content electrodes have been prepared with equivalent performance to state-of-the-art SPEFC electrodes containing 60 times more platinum. The objective of this project is to develop and extend this technique to prepare high-platinum-content (i.e., equivalent to state-of-the-art platinum contents) electrodes with improved efficiency. Such electrodes are critical enabling component technologies for high-efficiency, regenerative fuel cells.

Potential Commercial Applications: Applications could appear in high-efficiency and high-energy-density power systems for use in submersibles.

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214 JPL
90-1-10.06-1140 NAS7-1131
Overcharge Protection Additives for Rechargeable Lithium Batteries
Covalent Associates, Inc.
52 Dragon Court
Woburn, MA 01801
Victor R. Koch (617-938-1140)

High-energy-density, rechargeable lithium batteries are being considered by NASA for future manned and unmanned missions. Because lithium batteries containing non-aqueous electrolytes are highly sensitive to overcharge, especially when individual cells are connected in series, an adequate overcharge protection mechanism must be incorporated into the cell design. Phase I addresses this need by exploring the addition of several robust redox couples to the non-aqueous electrolyte. These additives are electroactive just positive of the normal cell cutoff voltage on charge and negative of irreversible electrolyte oxidation potential. Preliminary tests suggest that this particular class of redox couples will also enhance the cycleability of the Li electrode and suppress electrolyte reduction. During Phase I the long-term chemical and electro-chemical stability of these materials will be assessed prior to subjecting them to cycling in Li/TiS_2 cells and multicell batteries.

Potential Commercial Application: Reliable high-energy density, rechargeable batteries with specific energy density of 200 Wh/kg capable of undergoing in excess of 500 deep discharge cycles will find use in satellites and other NASA programs, portable communications equipment, and other consumer products currently employing Ni-Cd batteries.

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215 JPL
90-1-10.06-9450A NAS7-1142
New Electrolytes for Secondary Li/TiS_2 Cells
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Dennis N. Crouse (617-769-9450)

The key to widespread application of rechargeable lithium cells is an electrolyte that does not undergo reactions leading to cell venting under all likely conditions of cell abuse (electrical, mechanical, or thermal). This project will synthesize a number of new lithium salts and characterize their performance as electrolytes in Li/TiS_2 cells. Characterization will include conductivity, stability in contact with lithium and TiS_2, and effects on the cycling behavior of the cell. Promising electrolytes will be further evaluated in cycled Li/TiS_2 cells at temperatures above the melting point of Li.

Potential Commercial Application: A safe, well-behaved lithium salt with high conductivity will make possible the general use of Li/TiS_2 and other rechargeable Li cells.

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216 JSC
90-1-10.07-1353 NAS9-18472
Recharcheable Zinc-Air Cell
MATSI, Inc.
1565 Woodington Circle, Suite 205D
Lawrenceville, GA 30245
Ronald A. Putt (404-921-1353)

This project could provide NASA with safe, rechargeable batteries that have 10 times the specific energy of those currently available, and that could have a wide variety of applications on the Space Station Freedom. Unfortunately, the specific energies of all other available, rechargeable batteries are too low. Those for lead-acid and nickel-cadmium are only 35 Wh/kg and, although that of nickel-hydrogen is somewhat higher at 55 Wh/kg, it has a low energy density that, at only 60 Wh/l, makes it rather bulky. In contrast, the zinc-air battery has the highest specific energy of all practical battery systems, including lithium, and is inherently safe. Currently, however, it is manufactured only in small button cells and bulky, low rate industrial batteries, both of which are non-rechargeable. Nonetheless, recent advances in rechargeable zinc and oxygen electrode technology present an opportunity to develop a rechargeable zinc-air battery with a specific energy of 350 Wh/kg.

Potential Commercial Application: Low-power applications could be in portable electronic and electrical products such as two-way radios, cellular telephones, medical telemetry, instrumentation and test equipment, audio- and video-tape equipment, household appliances, power tools, portable computers, and oceanographic and meteorological equipment. High-power applications are possible for vehicle and aircraft SLI, vehicle traction, emergency and standby power, lighting, and utility load leveling.

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217 JSC
90-1-10.07-1460 NAS9-18483
Evaluation of Zinc-Oxygen Cells with Advanced Components
Energy Research Corporation
3 Great Pasture Road
Danbury, CT 06813
Sivaswamy Viswanathan (203-792-1460)

Recent component technology innovations will be applied to the design of rechargeable zinc-oxygen cells. The zinc-oxygen couple has long been recognized as having the potential for very high energy density; however, the system has been limited by problems with oxygen-electrode stability and zinc-electrode shape change. The objective of this project will be to demonstrate the feasibility of using advanced bifunctional electrode materials and separators in the battery. These component technologies will be applied to the zinc-oxygen cell in a six-month program of cell fabrication and testing. The development of a high-energy-density, zinc-oxygen battery with an extended life cycle will provide a technology that meets many commercial and aerospace needs. The need for portable power for Space Station equipment could be met by the battery. Given the safe nature of the battery reactants and its

inherent high energy density, the zinc-oxygen system is one of the few that can meet the energy-density and safety concerns for aerospace uses.

Potential Commercial Application: Applications of the zinc-oxygen battery could range from portable consumer electronics to advanced electric vehicles.

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218 JSC
90-1-10.07-9892 NAS9-18451
Research on Materials and Methods of Construction for Thermovoltaic Cells and Batteries
Energy Innovations, Inc.
8709 Knight Road
Houston, TX 77054
Meredith C. Gourdine (713-790-9892)

NASA needs reliable, safe, high-performance batteries to solve some demanding tasks on Space Station missions planned for the 1990s. Thermovoltaic cells and batteries offer possibilities beyond those of commercially available batteries and of other batteries now under development, which not only fail to meet the performance requirements, but in many cases present severe safety problems. This project will determine optimum combinations of materials and methods of construction for vapor-volt cells operating near ambient temperature, but damp. Experiments will be performed and the theory will be refined until the cells can confidently be applied to designing large, practical, space power systems. It is anticipated that a vapor-volt battery of 1 watt, having specific stored energy of 1000 watt-hr/lb, is feasible.

Potential Commercial Application: Vapor-volt cells are candidates for meeting demanding tasks on space missions in the 1990s.

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219 LeRC
90-1-10.08-3800 NAS3-26148
Passively Cooled, High-Temperature Superconductive Bus for Space Power Systems
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Christopher J. Crowley (603-643-3800)

As space systems tend toward higher power levels (10 to 100kw), the bus connecting the power source with the spacecraft becomes a very significant power distribution component in terms of weight, reliability, and efficiency. Present approaches use either massive, high-voltage, conventional copper conductors or actively cooled, low-temperature, metallic superconducting materials. This project will build and demonstrate a passively cooled space power distribution busbar using recently developed, high-temperature superconducting (HTS) materials. The use of HTS materials takes advantage of low-voltage, low-resistive loss characteristics similar to conventional superconductors, while the increased operating temperatures make it feasible to eliminate the cryocooler component by using passive radiative heat transfer to space. Compared with the alternatives, the HTS system will have the benefits of less mass (less cross-sectional area to carry the current), greater reliability (by not requiring cryocoolers or high-voltage meteor-proof enclosures), and reduced needs for power conditioning equipment. This project will determine the feasibility of demonstrating the HTS busbar approach in Phase I. A demonstration test, using prototypical component hardware, will be performed in Phase II.

Potential Commercial Application: The application of this technology will be fundamental to future satellites and space platforms having higher power requirements, and therefore of interest to manufacturers of space power systems.

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220 LeRC
90-1-10.08-7831 NAS3-26235
Solid-State, Micromachined Pump for Space-Power-System Thermal Management
Research International, Inc.
24121 39th Avenue SE
Bothell, WA 98021
Elric W. Saaski (206-486-7831)

Micromachined liquid pumping and control devices for space thermal-management systems are the focus of this project. By using recent developments in micromachining, it may be possible to form voltage-actuated fluid-control elements using photo lithography and semiconductor-processing techniques. Generically, devices made in this way offer the possibilities of enhanced control, massive redundancy in terms of function, and low cost because of the semiconductor "wafer-like" manufacturing approach. The Phase I program is intended to show feasibility through a combination of functional modeling, the construction of prototype micromachined hardware, and testing.

Potential Commercial Application: The devices to be developed have potential commercial use in the medical arena for liquid-flow control and for the cooling of avionic and ground-based electronic equipment.

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221 MSFC
90-1-10.08-9399 NAS8-38899
Hermetically Sealed, Aluminum-Electrolytic Capacitor
Boundary Technologies, Inc.
366 Lexington Drive
Buffalo Grove, IL 60089
Robert Alwitt (708-537-9399)

A hermetically sealed, aluminum-electrolytic capacitor will be developed as a replacement for tantalum capacitors in space power systems. This will significantly reduce power supply volume and weight. These capacitors will operate from -55°C to 105°C, have an estimated 20-year life, and have a high CV product: for example, 1000μF250 WV. The availability of a family of such components will make it easier to design higher power circuits. The innovations leading to this new capacitor are a novel seal design that avoids the

problems associated with an aluminum-glass bond, and a low-gassing electrolyte that limits the internal pressure during the operating life to safe levels. In Phase I, prototype electrolytes will be developed and tested, and gas-generation data will be obtained from which estimates will be made of internal pressure over operating life at different conditions. These estimates will demonstrate the feasibility of this device. The seal could be developed in Phase II.

Potential Commercial Applications: Applications for a hermetically sealed, electrolytic capacitor are found in commercial satellites and in medical electronic implants.

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11: Space Propulsion

222 MSFC
90-1-11.01-1515 NAS8-38904
Large-Eddy Simulation of Combustion in Liquid-Fuel Rockets
Cambridge Hydrodynamics, Inc.
P.O. Box 1403
Princeton, NJ 08542
Alex Yakhot (609-683-1515)

The design, optimization, simulation, and testing of liquid-fuel rocket engines involves a wide variety of geometrically complex, unsteady, turbulent, multidimensional reactive flow problems. In a high Reynolds number flow, the details of the (thin) flame fronts cannot be resolved, even on the most sophisticated supercomputer. This problem will be solved using large-eddy simulations (LES), in which the flow equations are solved at moderate-to-large length scales and the unresolved small scales are modeled using renormalization group methods. Large-eddy simulations of the reactive flow will give the precise position and shape of the flame front, while the energy equation with a heat source at the flame front will give the temperature field and, hence, the reaction rates and species distribution. In this way, LES will give detailed, accurate modeling of liquid-fuel rocket-engine dynamics.

Potential Commercial Applications: Many problems of direct industrial interest involve complex combusting reacting flows. With the LES techniques developed here, they will be treatable for the first time.

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223 MSFC
90-1-11.03-8400 NAS8-38900
Failure Criteria for Carbon-Carbon Contour-Woven Integral-Throat-Exit-Cone Materials
Materials Sciences Corporation
930 Harvest Drive, Suite 300
Blue Bell, PA 19422-1959
John J. Kibler (215-542-8400)

This project will develop an analytical model capable of predicting failure of carbon-carbon (C-C) materials. The model will build upon the firm's in-house C-C analysis codes and will develop demonstrated capability to predict failure of C-C composites. In particular, methods for analyzing C-C materials, such as the contoured weave designs being developed for application to NASA's Advanced Solid Rocket Motor, will be developed. Verification of the model's predictive capability will be accomplished through correlation of existing C-C experimental data.

Potential Commercial Applications: The analytical method developed under this effort will predict failure in C-C materials under thermal stresses induced in service conditions. The resulting failure criteria will be useful for predicting the margins of safety for all future C-C integral-throat-exit-cone materials.

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224 MSFC
90-1-11.03-8900B NAS8-38912
Rotated Ply Stacking for Carbon-Carbon Cloth-Based Nozzle Components
PDA Engineering
2975 Redhill Avenue
Costa Mesa, CA 92626
Douglas A. Marx (714-540-8900)

The sensitivity of the thermostructural performance of rocket nozzles to changes in carbon-carbon composite material properties has been a significant problem. Results of an Air Force study have clearly indicated that significant gains in structural reliability could be achieved by adopting a rotated ply stacking sequence with WCA-based, two-dimensional carbon-carbons. This project will examine the potential for improvement afforded by using a rotated ply stacking sequence. The study will entail conducting thermostructural analyses of the CCT-4 motor, using a carbon-carbon exit cone that features a rotated ply construction. A quantitative assessment will be made of the degree of improvement afforded by a rotated ply construction; the optimum ply stacking arrangement will be identified as well. Producability studies will be conducted with information from material suppliers; they will ascertain the feasibility of manufacturing rotated ply patterns suitable for carbon-carbon, cloth-nozzle components, as well as identify any potential difficulties or limitations inherent in rotated ply construction.

Potential Commercial Application: An alternative and low-risk way to increase significantly the reliability of two-dimensional, carbon-carbon nozzle components would be of particular value to NASA and the space motor industry.

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225 LeRC
90-1-11.04-6052 NAS3-26239
Impingement-Sheet Mixing for Injection of Liquid Propellants in Rocket Engines
Liquisheet Technologies
4654 San Sebastian Avenue
Oakland, CA 94602
Robert J. Demyanovich (415-530-6052)

The objective of this project is to evaluate the use of impingement-sheet mixing, a novel, recently developed

mixing process, for injecting liquid propellants into rocket engines. Earlier work has demonstrated that impingement-sheet mixing is one of the fastest liquid-phase mixing technologies available and could potentially be advantageous in rocket injectors. The experimental program to be performed in Phase I will provide preliminary estimates of the liquid-phase micromixing time of impinging sheets at velocities typical of rocket injectors. Liquid-phase micromixing times will also be estimated for conventional rocket injectors using impinging jets. Comparisons of the results will be made to evaluate the potential use of impingement-sheet mixing as an alternative design for rocket injectors. A Phase II would investigate the effect of injection Reynolds number on liquid-phase mixing rate for both impinging sheets and impinging jets.

Potential Commercial Application: As a result of this project, impingement-sheet mixing might be applied in the chemical-dye industry, the photographic-film industry, and reaction-injection molding.

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226 LeRC
90-1-11.04-8061 NAS3-26243
Mixed Hafnium-Tantalum-Carbide Composite Rocket-Thruster Development
Refractory Composites, Inc.
12220-A Rivera Road
Whittier, CA 90606
Edward L. Paquette (213-698-8061)

Recent Air Force-funded, arc-jet materials testing has demonstrated that a mixed HfC-TaC composite ceramic material exhibits the lowest mass loss of any material tested, including hafnium carbide and hafnium diboride ceramic composites. A hydrogen-oxygen propellant rocket thruster, based on the mixed hafnium-tantalum-carbide ceramic composite, is expected to demonstrate superior high-temperature durability under stoichiometric hydrogen-oxygen propulsion conditions, when operated exclusively as a radiation-cooled thruster. Phase I includes the development of tubular composites of HfC-TaC matrix with graphite-fiber reinforcement. Fabrication of convergent-divergent sections will be performed as well. Prototype thruster articles suitable for stoichiometric hydrogen-oxygen combustion evaluation at NASA-Lewis will be delivered in Phase I. Phase II work would focus on the development of thrusters in the 5,000 lb thrust class or smaller. The payoffs from such technology are reduced thruster weight, cost, and complexity. Also, dramatic improvements in specific impulse result from the elimination of excess fuel, which is injected in the combustion wall region to avoid overheating temperature-limited metallic thrusters.

Potential Commercial Application: This work applies to engines for commercial launch, payload auxiliary propulsion, and attitude control.

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227 LeRC
90-1-11.05-0236 NAS3-26241
Unconventional, Long-Life Chemical Rocket-Thrust Chambers
Ultramet
12173 Montague Street
Pacoima, CA 91331
Robert H. Tuffias (818-899-0236)

Current chemical rocket-thrust chambers have limited lives due to the limited oxidation protection currently available. This is true not only at temperatures of 2200°C (4000°F), but at 1100°C (2000°F) as well. A prime example is the space shuttle orbiter vernier thruster. Through an innovative application of vapor-solid processing, a material has been developed that can be applied as a protective coating with outstanding oxidation-protective results. Phase I will demonstrate its applicability to protecting chemical rocket-thrust chambers from oxidation. This material has the potential to extend thrust-chamber lifetimes by an order of magnitude.

Potential Commercial Applications: Extended thruster lifetimes would translate directly into cost savings for commercial satellites and shuttle orbiter vernier thrusters.

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228 LeRC
90-1-11.08-1010 NAS3-26238
Improved, Fiber-Optic Temperature Sensors for Propulsion Systems
Tacan Corporation
2330 Faraday Avenue
Carlsbad, CA 92008
Ron Grayson (619-438-1010)

Methods will be investigated to improve on the upper temperature limit, response, and durability of fiber-optic sensors for high temperatures. Present high-temperature, fiber-optic sensors (both commercially available products and laboratory prototypes) use sapphire rods, tubes, or fibers that become significantly less resistant to thermal shock and physical stresses at the upper end of their useful temperature range (1950°C). A way to increase the temperature limit involves using refractory waveguides, including carbides, nitrides, and certain metals plus their alloys. Response and accuracy can be improved through increases in the emissivity of the probe tip and decreases in thermal mass. Durability may be improved with special coatings or by embedding probes in other refractory materials. This project will identify several viable materials and methods to be used in fabricating probes that can not only survive a long time at high temperatures in harsh environments, but also provide highly accurate temperature data in a fiber-optic sensing system. In addition to providing accurate temperature measurement in rocket engines, a fiber-optic sensor using these probes will be of great value in fields such as metallurgy, semiconductor processing, and combustion research.

Potential Commercial Application: Fiber-optic temperature sensors will find application in the monitoring of turbine and rocket-engine components and

combustion chambers, internal-combustion engine research, metallurgy, glass manufacturing, and semiconductor processing.

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229 LeRC
90-1-11.08-5061 NAS3-26240
Fiber-Optic Cable Feedthrough and Sealing
Litecom, Inc.
20249 Elkwood Street
Canoga Park, CA 91306-2313
Robert J. Fan (818-882-5061)

This effort involves development of fiber-optic cable feedthrough and sealing for sensor and multiplexed fiber-optic data bus concepts in cryogenic liquid-propulsion system environments. This development includes assessing current sealing material and techniques to see if they meet cryogenic liquid propulsion system requirements; devising a new method to construct the hermetic seal, fiber-optic feedthrough; and developing a method to increase the fiber-optic backshell's ability to survive in propulsion-system environments.

Potential Commercial Applications: These results would be useful to manufacturers of both civilian or military equipment: it would improve their reliability, accuracy of measurement, and data transmission.

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230 SSC
90-1-11.09-5649 NAS13-439
High-Frame-Rate, Imaging Spectrometer for Rocket Plume Diagnostics
Daedalus Enterprises, Inc.
P.O. Box 1869
Ann Arbor, MI 48106
Steven D. Cech (313-769-5649)

This high-frame-rate, imaging spectrometer will measure the transient temperature and chemical composition of the gases in a rocket plume. An innovative, high-throughput, holographic-grating spectrometer that images one spatial line and disperses the spectra in a second dimension across a two-dimensional imaging array will be developed. High-frame-rate imagers for the 0.4 to 1.1 μm wavelength range and for the 1.1 to 2.2μm range are proposed. The extension of this spectral range to 0.3-1.1 μm will be considered. This broadband coverage allows measurement of the plume temperature and chemical composition. Multispectral line images can be obtained at a rate of 24,000 per second in the UV and near-IR, and up to 1,000 per second in the thermal IR. A rotating mirror can frame the line images into two-dimensional images at a slower frame rate. High-speed processors and data recorders will be used to process and store data for post-test analysis. The imaging spectrometer will permit NASA to obtain data on the transient characteristics of the combustion processes that can be observed in the exhaust plume. The high cost of test articles for rocket-engine tests requires the accumulation of the most complete diagnostic data possible.

Potential Commercial Application: Commercial launch vehicles are a market for the instrument, as well as NASA and DOD. Other commercial applications include plasma diagnostics and any dynamic combustion tests.

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231 SSC
90-1-11.09-6522 NAS13-437
An Ultra-High-Resolution Anomalous Specie Detection System for SSME Engine Plumes
Duncan Technologies, Inc.
P.O. Box 1150
Newcastle, CA 95658
David B. Duncan (916-888-6522)

A very sensitive detection system will be developed to measure concentrations of metallic species in the space shuttle main engine (SSME) plume at the nozzle exit. The system will have a detection range from 1 ppb to 1000 ppb, allowing de-tection of wear and incipient failure. It is non-intrusive, can operate on tests stands with and without a diffuser in place, and uses narrow-line absorption to measure concentrations. A reference wavelength is monitored to separate broadband absorption, refraction, and optics contamination from atomic line absorption. Phase I will determine the detection range achievable using a theoretical analysis. A system will be designed and demonstrated using the DTF engine at SSC. Conceptual designs of a full-scale test stand instrument will be completed. Phase II would produce a full-scale, test-stand instrument for installation on an SSME test stand at SSC.

Potential Commercial Applications: The system could be used on industrial exhaust stacks, waste-burning facilities, and power plants to detect toxic effluents and on all commercial, NASA, and Air Force rocket- and jet-engine test stands.

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12: Human Habitability and Biology in Space

232 JSC
90-1-12.01-3623 NAS9-18470
Hand Physiological Evaluation and Countermeasure Device
Loredan Biomedical, Inc.
1632 Da Vinci Court
Davis, CA 95617
Malcolm Bond (916-758-3622)

The firm will design a proof-of-concept prototype system of a hand musculoskeletal prototype system (HMS). The HMS will be able to assess and maintain the physical condition of the hand. A computerized, comprehensive menu of exercise modalities will be designed that will allow the HMS specifically to emulate selected job tasks, as well as generic skilled movements. The planned approach to generic hand movements will constitute a new and innovative hand-eye and mechano-sensory-receptor-based coordinated assessment and training tool. This theory will be proved

in proof-of-concept fashion using existing commercial products of the company as well as mechanical prototype design that has the hand-grasp motion translated into a rotational-resistance mechanism, and control software that evaluates and trains generic and job-task movements of the hand. Phase II would concentrate on the fabrication of a flight prototype for conceptual evaluation of a planned shuttle/Space Station healthcare device.

Potential Commercial Applications: This device could be used in motor-coordination screening of job applications; motor-coordination and contractile-muscle performance quantification of the cerebral-insult patient population; training for maintenance and improvement of muscular strength and endurance through the application of functional, isokinetic exercise; training for maintenance; and improvement of skeletal range of motion of each hand digit.

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233 JSC
90-1-12.01-5090 NAS9-18484
A Portable, Dark-Focus Instrument
Essex Corporation
1040 Woodcock Road, Suite 227
Orlando, FL 32803
Robert S. Kennedy (407-894-5090)

Neurobiological research indicates that changes in accommodation are associated with stresses that may occur during space missions (e.g., extended duration flight, variable gravity, long-term confinement, space motion sickness). The consequences of this for the national space program are twofold. Measures of accommodation may be used to index onset and extent of space motion sickness and other stresses of spaceflight, both after entry to hypogravity conditions and during readaptation to terrestrial conditions. An accurate measure of accommodation may be used to signal that visual performances may be degraded. The primary objective of this project is to develop, calibrate, and validate a portable device to measure accommodation. In Phase II, fabrication and extensive field testing of the device would be conducted.

Potential Commercial Applications: A sophisticated device to measure accommodation could be used to signal the impairment of subject state mediated by autonomic activity, as well as the direct reduction of visual-detection performance, and would have use both in the military and private sector. It could also have application in personnel selection, task analysis, and the quantification of visual fatigue.

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234 JSC
90-1-12.01-9769 NAS9-18466
A Hand-Held, Medical Diagnostic Ultrasound B-Mode Scanner with Doppler
Coherent Systems, Inc.
1000 Bay Area Boulevard, Suite 206
Houston, TX 77058
Edward W. Leahey (713-488-9769)

A hand-held medical ultrasound instrument for cardiology—weighing 10 pounds, occupying 0.1 cubic feet of space, and complete with two-dimensional imaging, EKG display, Doppler, and digital image storage—is a significant innovation in diagnostic devices. Capable of imaging the heart, the great vessels, and intra-abdominal organs with performance comparable to that of a full-sized instrument, this novel device could be used both on board spacecraft or in the laboratory to aid in the health care of astronauts. The objective of this project is to produce such a device by exploring strategies for miniaturizing major functional areas of two-dimensional, ultrasound imaging systems. Specifically, the project will investigate a novel beamforming technique; design a digital-scan convertor using application-specific, integrated-circuit technology; design a low-component-count, single-channel EKG system; demonstrate the feasibility of Doppler spectral calculations using a digital signal processor; and investigate the feasibility of onboard storage using data-compression techniques. The feasibility report at the end of Phase I will permit the development of full-scale prototypes usable by NASA during Phase II.

Potential Commercial Applications: Initially targeted for use by cardiologists, this device could create new markets for the application of diagnostic ultrasound in conducting general exams by primary-care physicians; for assessing trauma in the battlefield or other emergency situations by paramedical personnel; and as an aid to establishing central intravenous lines.

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235 MSFC
90-1-12.02-0054 NAS8-38920
Intelligent Processor for Space-Station Life-Support System
Ktaadn, Inc.
1340 Center Street, Suite 202
Newton, MA 02159
Donald S. Frankel (617-527-0054)

This project involves a new approach to the processing of air- and water-quality-monitoring data on board the Space Station. Fire detection and classification by type will also be enhanced. Attractive features of the processor will include: parallel processing for high speed with minimum weight, space, and cost; easy adaptability (without resorting to programming) to changes in the complement of monitoring devices or the presence of new contaminants; robustness with respect to noise, component failure, or missing data; and the ability to accept and merge data of different types for improved diagnosis. The innovative data processor will include neural-network technology that will be responsible for many of its attractive features. Using the array of gas chromatographs, mass spectrometers, and other sampling and measuring devices on board, the processor will allow for rapid data analysis, fault diagnosis, and response to dangerous situations.

Potential Commercial Applications: Intelligent processing of mass spectral data will improve the quality of environmental monitoring on Earth.

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236 JSC
90-1-12.02-0769 NAS9-18464
Chemiluminescent Deoxyoligonucleotide Probes for the Rapid Detection of Bacteria
Biophotonics, Inc.
4342 West Tesch Avenue
Greenfield, WI 53220
Reinhardt A. Rosson (414-543-0769)

Because bacterial diseases are frequently transmitted through contaminated water, the detection of microbiological contamination is important, to ensure sanitary water supplies. Current tests are labor intensive and take several days to confirm contamination levels. This project will demonstrate the feasibility of a unique, rapid, water-quality test for bacteria. Phase I focuses on the development of specialized chemiluminescent deoxyoligonucleotide probes. These DNA probes will complement universal bacterial, coliform-group, and E. coli-specific ribosomal RNA (rRNA) sequences and, as a result, will hybridize only when one of these sequences is present. Thus, it will be possible rapidly to detect bacterial contamination. To produce a visible response, chemiluminescent agents will be covalently linked to the deoxyoligonucleotide probes. The probes will be short—15 to 25 bases long—allowing intact cells to be probed without first extracting the target rRNA. To measure and quantitate the chemiluminescent emission, a number of commercially available light detectors, including field-portable units currently in development by the firm, will be tested. Using these new probes, the number of bacteria in water samples should be determined in as little as one hour.

Potential Commercial Applications: The product will be simple, quick, and sensitive tests for determining total bacterial contamination, as well as the sanitary quality of any water supply. Potential applications include field testing, home test kits, and on-line, real-time monitoring for use in the United States and abroad.

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237 JSC
90-1-12.02-1545 NAS9-18465
Non-Invasive Blood Analysis During Manned Space Flight
Boston Advanced Technologies, Inc.
656 Beacon Street
Boston, MA 02215
Edward Sinofsky (617-267-1545)

A spectroscopic approach will be developed for analysis of blood during manned space missions. The analysis will be performed directly through the skin by using light from a laser diode array that is reflected from a prominent vein near the skin surface, in either the wrist or ankle region of the body. The laser diodes will operate at low power, causing no tissue injury, and at specific wavelengths in the red and near-infrared wavelengths, at which skin and venous tissue are known to be transparent to a depth of several millimeters. The reflected light at each of the selected probe wavelengths will then be measured. The reflected intensities from each probe wavelength are analyzed in two modes. First, the specific reflectance ratios among the probe wavelengths will be determined and used to identify blood components present in the monitored patient's circulatory system. Then, if the ratios of key selected wavelengths remain unchanged, the reflectance intensity will be used to monitor changes in red-cell (hematocrit) concentration.

Potential Commercial Applications: A non-invasive blood monitor would have wide uses in medical practice.

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238 MSFC
90-1-12.02-3648 NAS8-38891
Organic Contaminant Monitor
TPL, Inc.
1549 Glorieta NE
Albuquerque, NM 87112
Ronald E. Allred (505-296-3648)

Acoustic place mode (APM) devices are extremely sensitive to small mass changes at their surfaces (ng/cm2) when immersed in liquids. Combined with a properly derivatized surface, they are capable of detecting trace organic constituents in water. An APM device sensor with a plasma polymerized surface will be developed as a precursor to an automated monitor for organic species in reconstituted water. The sensor will be lightweight, extremely accurate, highly durable, reliable, and will consume little power. Modification of the surface coating will create a family of sensors for a wide variety of chemical species.

Potential Commercial Applications: These devices will find a variety of applications in the electronic, chemical, and medical industries, in which trace organic contaminants affect product quality. They may also be used for monitoring organic and inorganic contaminants in groundwater.

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239 JSC
90-1-12.02-6800 NAS9-18468
Quantitation of Radiation Effects on Human Cells
DNA Sciences
8058 El Rio
Houston, TX 77054
Howard G. Gratzner (713-748-6800)

Measuring the effects of ionizing radiation on cells of the immune system and devising methods to protect humans against radiation damage are essential to long-duration space travel. The overall objective of this project is to develop flow cytometric methods for monitoring radiation damage to lymphocytes, and to assess chemical agents for their ability to serve as radioprotectors. The response of human mononuclear cells to increasing levels of radiation will be gauged by parallel assays on cells isolated from normal individuals. The cells will be irradiated with increasing doses of gamma radiation and the effects of various parameters will be measured on the same cell population: immune response by immunofluorescence measurement of DNA replication and DNA content; cytotoxicity of natural killer (NK) cells; and intracellular glutathione levels. Threshold levels of impairment of these parameters will be determined, and the ability of radioprotective agents to

modulate them will be determined. The information and technology developed should be valuable to NASA and for application to commercial, biomedical technology.

Potential Commercial Applications: Applications include: clinical laboratory testing for both immune system dysfunction and cancer; genetic toxicology and carcinogenesis testing; and applications to radiology and radiotherapy. Radioprotection of the immune system during cancer radiotherapy could lead to new methods for increasing the radiation dosage to tumors while sparing radiation to bone marrow.

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240 ARC
90-1-12.03-0369 NAS2-13346
Wiped-Film Rotating-Disk Evaporator for the Reclamation of Water At Zero Gravity
Tielmat & Associates
75 Ina Court
Alamo, CA 94507
Badawi Tielmat (415-838-0369)

The existing design of the high-performance, wiped-film rotating-disk (WFRD), vapor-compression distillation (VCD) unit will be modified for operation at zero gravity. Because of its very high heat-transfer coefficient and low energy requirement, the modified WFRD unit has the potential of reducing the size and weight of the VCD subsystem, as well as reducing the mechanical energy required to drive it. In this project, thermodynamics, fluid mechanics, and heat-transfer calculations will be made to accommodate zero-G operation, as well as capacity requirements for manned spacecraft missions. The existing design of the WFRD will be modified for operation at zero gravity. Two detailed designs will be made: a simple VCD design and a two-effect design. The two designs will be compared to weigh the thermodynamic advantages of the two-effect design against the additional components needed for its construction.

Potential Commercial Applications: Applications would be in producing double- or triple-distilled water for the pharmaceutical industry, distilling water for the water-bottling industry, desalting, and cleaning impaired waters. The small-apacity unit produced by this project could be used in photographic shops to reduce, in situ, the volume of toxic photographic waste solutions before disposal.

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241 MSFC
90-1-12.03-3648 NAS8-38909
Aerogel Processing of Ceramic-Composite Membranes
TPL, Inc.
1549 Glorieta NE
Albuquerque, NM 87112
H. M. Stoller (505-296-3648)

Bioregenerative processes stress membrane performance requirements, increasing the need for a viable ceramic membrane technology. Sol-gel derived membranes that are processed by supercritical fluid extraction (aerogel) techniques offer the potential of net-shaped, low-cost fabrication, with precise control of membrane pore structures. Combined with ceramic fiber reinforcement, the aerogel ceramic process permits the fabrication of tough, low-cost, high-performance, structural-membrane-material systems. The feasibility of using sol-gel/aerogel processes to fabricate ceramic-composite membranes, with controlled pore size and pore-size distribution, will be demonstrated. This will result in the development of a membrane technology with high-performance, ultra-filtration capability. Silicon nitride-reinforced mullite will be used as a model material system. Membrane disks will be aerogel processed, and chemically aged and infiltrated to control membrane pore size and pore-size distribution. Characterization will include thermal stability, mechanical properties, pore size and pore-size distribution, and transport properties.

Potential Commercial Applications: The resulting membrane could be suitable for extreme applications, including high-temperature, oxidative, and corrosive environments. Applications include gas separations and catalytic supports.

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242 JSC
90-1-12.03-4100 NAS9-18477
Reverse-Osmosis Membranes for Removal of Low-Molecular-Weight Organics from Water
Bend Research, Inc.
64550 Research Road
Bend, OR 97701-8599
Rod J. Ray (503-382-4100)

Reverse osmosis is a membrane process that has the potential to improve significantly waste-water recycling technology for use in space, and to eliminate or reduce the need for the expendable polishing beds required by existing waste-treatment subsystems. However, to realize this promise, reverse-osmosis (RO) membranes must be developed that can remove low-molecular-weight organics from waste water. This project will develop such a new class of RO membranes. The goal of the Phase I program is to demonstrate that low-molecular-weight organics can be rejected by RO membranes made from materials selected specifically for this application. In a subsequent Phase II, these membranes would be optimized. Prototype modules containing these membranes would then be synthesized and extensively tested. Full-scale modules would be delivered to NASA for use in RO systems currently owned by NASA.

Potential Commercial Applications: The RO membranes developed in this project could provide an attractive alternative to current waste-treatment methods, enabling the economical treatment of many hazardous-waste streams.

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243 MSFC
90-1-12.03-4100A NAS8-38902
A Membrane-Based Atmosphere-Control Subsystem
Bend Research, Inc.
64550 Research Road
Bend, OR 97701-8599
Scott B. McCray (503-382-4100)

Integrated physicochemical, biological closed-loop life-support systems must be developed for humans to undertake extended extraterrestrial missions. These systems almost certainly will include separate but integrated plant and human habitats, not only to provide food for humans and recycle their waste, but also to replenish the atmosphere. No such system currently exists. This project will develop a membrane-based, atmosphere-control (MBAC) subsystem to separate oxygen from nitrogen and to enhance the removal of carbon dioxide and water vapor for controlled redistribution between the plant and human habitats. The immediate use of this system would be to aid NASA in the developmental studies of these habitats. The aim of Phase I will be to develop a computer model for such a system at steady state. and to refine the model through tests of a bench-scale apparatus that simulates the MBAC subsystem. In Phase II, the model would be further refined to address a more realistic, dynamic state, with the aim of building a preprototype MBAC subsystem.

Potential Commercial Applications: The computer models developed in this program would help to improve commercial membrane systems that separate oxygen from nitrogen to produce either oxygen- or nitrogen-enriched air. In addition, future farmers may use closed environments and controlled atmospheres for optimum food production.

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244 JSC
90-1-12.03-7071 NAS9-18473
Supercritical Water-Oxidation Reactor for Space Applications
MODAR, Inc.
14 Tech Circle
Natick, MA 01760
Glenn T. Hong (617-237-7071)

Supercritical water oxidation (SCWO) has been shown to be a promising technique for water recovery and waste management in space. The key piece of equipment in this technology is the reactor, which must allow oxidation to occur as it simultaneously deals with the precipitation of sticky solids. Prior work for NASA has identified the concept of an "impingement canister" as most likely to succeed. This project covers the gathering of design data to allow construction of the first impingement-canister reactor with a solids separator. In Phase II, the reactor would be built and incorporated into a preprototype unit dedicated to space applications.

Potential Commercial Applications: This project will broaden the existing database of information used to design SCWO systems for terrestrial usage in, for example, the destruction of hazardous waste.

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245 ARC
90-1-12.04-4100A NAS2-13345
A Membrane-Based Subsystem for Water-Vapor Recovery from Plant-Growth Chambers
Bend Research, Inc.
64550 Research Road
Bend, OR 97701-8599
Rod J. Ray (503-382-4100)

NASA is investigating the use of plant-growth chambers (PGCs) for space missions and for bases on the moon and Mars. PGCs serve several important purposes: oxygen and food production, carbon-dioxide removal, and water purification and reuse. Key to the successful development of PGCs is a system that will recover and reuse the water vapor transpired from the leaves of the growing plants. This project will develop a simple, reliable, membrane-based system that allows the recovery, purification, and reuse of the transpired water vapor through control of temperature and humidity levels in the PGC. This system has characteristics that make it ideally suited to use in space: minimal power requirements, small volume and mass, simplicity, reliability, and versatility. In Phase I, an accurate, predictive model of the firm's temperature and humidity-control system will be developed, based on parametric tests of membrane modules. This model will be used to design systems for selected PGCs. Phase II would focus on the design, fabrication, testing, and delivery of a breadboard unit to NASA for testing on a PC.

Potential Commercial Applications: The technology developed in this project could provide an alternative to air-conditioning systems based on chlorinated fluorocarbons.

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246 KSC
90-1-12.04-7653A NAS10-11758
An On-Line Microbiological Analyzer
Biotronics Technologies, Inc.
12020 West Ripley Avenue
Wauwatosa, WI 53226
Kenneth J. Schlager (414-475-7653)

Microbiological monitoring will be a critical function in the biomass-processing reactors of the NASA Controlled Ecological Life Support System (CELSS). Measurement of cell density and cell activity in some reactors will allow for the automation and optimization of biochemical processes without the need for experienced skilled personnel. In other reactors, microbiological detection and characterization of bacterial contaminants will be required. All living cells, including micro-organisms, contain nicotinamide adenine dinucleotides (NAD) that serve as cofactors in many metabolic reactions. The reduced forms [NAD(P)H] are high-energy molecules that fluoresce at 460 nm when irradiated with light at 340 nm. This fluorescence property of NADPH may be used to measure microorganism cell concentration and activity using a fiber-optic fluorescence analyzer, such

as the Biotronics BI-401. The BI-401 is an on-line, fiber-linked, multiple-wavelength fluorometric analyzer that provides an ideal experimental vehicle for research in biochemical-process analysis and control. The multiple-wavelength nature of the BI-401 will allow for investigation of NADPH and other natural fluorophores such as tryptophan, tyrosine, and ATP. Cell mass and activity levels, along with cell metabolic state, will be the primary areas of investigation.

Potential Commercial Applications: Primary commercial markets for this technology potentially exist in the pharmaceutical, brewing, and waste-water treatment industries.

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247 KSC
90-1-12.04-8606A NAS10-11757
Compact Lighting Technology for CELSS Flight-Experiment Hardware
Phytoresource Research, Inc.
707 Texas Avenue, Suite 101-E
College Station, TX 77840
H.W. Scheld (409-693-8606)

Lighting requirements for flight experiments in plant growth vary from very high photon flux for photosynthesis and productivity to precise, narrow-spectral-band control, and/or absolute darkness for photomorphogenic control. Design guidelines for spacecraft environments require that the lighting systems be compact and efficient. In this project, a woven fiber-optic technology, heretofore used primarily for LCD-panel backlighting, will be adapted to the use of higher light intensity and filtered spectral control in a compact, locker-based unit designed for support of plant growth experiments in the shuttle mid-deck locker area. The design will integrate an inert, high-light-transmitting growth container. The state of development of these individual components is such that an integration of all components will result in a flight-ready hardware item.

Potential Commercial Applications: The hardware product of this effort is intended primarily for use by NASA-supported investigators of plant-growth experiments. A low-cost version of the unit may stimulate a market in the segment of the education community interested in flight experimentation.

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248 JSC
90-1-12.05-0700 NAS9-18449
Using Solar Illumination in Reduced-G Environments
BRW
2700 North Cental Avenue, Suite 1000
Phoenix, AZ 85004
Kyle D. Williams (612-370-0700)

The innovation investigated in this project is the use of direct sunlight and albedo for task and general illumination in reduced-G environments. The primary objective will be to design conceptually a solar-optic system for a lunar base, and to determine its power, mass, cost, and performance characteristics. The design will be compared with a conventional fluorescent-lighting system. The deliverable will be a technical feasibility report and recommendation for prototype development in Phase II. Solar optics is an approach to the transmission of light to remote interior spaces. It is chosen as the basis for this project because it has been successfully used in terrestrial applications and is uniquely suited for adaptation to reduced-G environments. Solar illumination offers an efficient alternative to electrically generated illumination; it can be twice as efficient as other light sources. Power requirements for a combined solar/artificial-lighting system are expected to be a small fraction of those for all electric sources. Supplemental electric luminaries can be safely isolated from occupied areas, and effective, lightweight optical materials are available.

Potential Commercial Applications: Applications include lighting for commercial, retail, and industrial buildings in industrialized and developing countries.

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249 MSFC
90-1-12.05-2075 NAS8-38910
A Force-Feedback, Anthropomorphic, Teleoperation Input Device for Control of Robot Hands
Exos, Inc.
8 Blanchard Road
Burlington, MA 01803
Beth Marcus (617-229-2075)

The innovation investigated in this project is a sensing and force-reflecting exoskeleton (SAFIRE) that provides control signals to robot hands and force feedback to the human operator. The SAFIRE will allow robot hands working in unstructured environments to touch objects gently and manipulate them finely without exerting excessive forces. Extravehicular activity (EVA) is sometimes unplanned, can require tool improvisation, and often requires fine manipulation. In order for the EVA Retriever, Flight Telerobotic Servicer, and Satellite Servicer Robot to reduce the work load on the EVA crew, they must be able to perform a wide variety of complex functions without reconfiguration. The use of a SAFIRE allows direct control via teleoperation, semi-autonomous operation via record and playback, and an essential understanding of the robot-task environment that is crucial for programming the autonomous operation of robots. The goal of Phase I is to design and build an integrated, two-degree-of-freedom prototype SAFIRE that can be used with various robot hands to study the interaction of robot hands with complex tasks in unstructured situations.

Potential Commercial Applications: The SAFIRE master has potential commercial applications in robotics and medicine.

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250 MSFC
90-1-12.05-3118 NAS8-38896
Alternative Illumination Technologies for the Human Habitation of Space
McGown, Mullican & Dunn
178 2nd Avenue North, Suite 301
Nashville, TN 37201
Raymond C. Mullican (615-254-3118)

To date, lighting deployed in spacecraft has not taken advantage of new light-source and optical-control technologies available to earth-based illumination systems. This project will review these new technologies for applicability to manned space programs, specifically demonstrating the innovative use of new sources that have not been previously used in human-task and ambient-illumination systems. New fluorescent, high-intensity-discharge, light-emitting-diode, electro-luminescent, and tritium sources will be investigated for advantages in mass, volume, power consumption, and performance life over present systems, as well as critical human factors, such as spectral power distribution, chromaticity coordinates, and color-rendering capabilities. Employing CADD, extensive luminaire design and analysis software, full-scale mockups, and appropriate sources will be integrated with new crystal, internal-reflective lenses and holographic films to demonstrate innovative, functional illumination systems for human habitation. Additional computer analysis will confirm considerations of direct glare, veiling reflections, and luminance distributions in the visual field, which are paramount concerns upon installation.

Potential Commercial Applications: Typically, electric lighting is the largest single energy user in current commercial buildings. New, energy-efficient light sources suitable for human habitation would have a major impact on this load profile and resulting operating expenses.

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251 ARC
90-1-12.05-9300 NAS2-13356
An Underwater, Remotely Operated Vehicle to Test Enhanced Human Interfaces
Deep Ocean Engineering, Inc.
1431 Doolittle Drive
San Leandro, CA 94577
Phillip J. Ballou (415-562-9300)

This project will develop an underwater, remotely operated vehicle (ROV) system designed to evaluate enhanced human interfaces with telerobotic and automated devices that may ultimately be used in space. The underwater environment offers an immediately accessible "space analog" in which to conduct these tests. Some of these concepts, such as specialized electronic-vision systems and audio-tactile sensors for manipulators, have already been proved in the underwater environment. They must, however, be examined for their viability in space. These and new ideas for human-machine interfaces may be tested efficiently and economically using this underwater experimental platform. Positional-correspondent control of the ROV, its video cameras, and manipulator system will help to provide the operator with a "telepresent" sense, that of physically being present at the remote site. Certain levels of computerized automation will be required to enhance the capabilities of the human operator. Ultimately, this development will result in a telepresent ROV capable of moderate scientific and industrial tasks. Its open-ended design will allow it to serve as a test bed for future telerobotic concepts that may apply to Space Station assembly, or to scientific research and exploration on Mars and other planets.

Potential Commercial Applications: Enhanced human interfaces that are developed for this project will find many useful applications in commercial, industrial, and scientific work underwater.

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252 JSC
90-1-12.06-7947A NAS9-18482
High-Definition, Full-Color, Virtual-Image Processing
Electronic Imagery, Inc.
1300 Park of Commerce Blvd, Suite 273
Delray Beach, FL 33445
Cindy Marie Seiffert (407-243-7947)

The problem with digitizing, performing-image processing, and enhancing high-definition, full-color images on personal and portable computers, is that the right combination of hardware and software does not exist to make the image process virtual size, full color, and independent of the image display. The project will produce image-processing software to enhance and manipulate full-color, virtual-size images on personal and laptop portable computers. The effort will also identify the hardware that would enable development of a prototype apparatus to maximize the speed and efficiency of the processing.

Potential Commercial Applicationss: The software would be of value in radiology, which has increasingly rigorous resolution requirements for effective quantitative analysis; in pathology, which requires higher degrees of resolution for diagnostic purposes in analyzing tumors, cell dysfunction, and so forth; and in printing-industry prepress applications for maintaining 35mm photographic quality, or better.

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253 ARC
90-1-12.07-7830 NAS2-13348
Integrated Carbon-Dioxide, Humidity, and Thermal Control for an EMU Gas Stream
TDA Research, Inc.
12421 West 49th Avenue #6
Wheat Ridge, CO 80033
Robert J. Copeland (303-422-7830)

An advanced absorbent has been identified for simultaneously removing carbon dioxide, humidity, and heat from the gas stream in an Extravehicular Mobility Unit (EMU). This absorbent eliminates several EMU components, reduces the size of others, and minimizes the mass and volume of the EMU. It will not vaporize and is not toxic. The system studied is completely closed and regenerable. No gases are vented during or after the Extravehicular Activity (EVA). The system

produces water and CO_2 at 1.0 atmosphere in separate streams. The heat sink capacity can be easily recharged. Based on previous application of the absorbent, the chemicals and equipment have the ability to operate several years without major repair or replacement. Based on practical component efficiencies, the advanced absorbent requires one-third the power for regeneration of other advanced CO_2 control technologies, including silver oxide. The absorbent also provides cooling to the EMU gas stream during EVA. The cooling capacity is restored by connection to a spacecraft cooling loop that operates at 4°C (40°F). No additional active refrigeration unit is needed to restore the heat-absorption capacity.

Potential Commercial Applications: A regenerable, portable breathing apparatus would be of use to firefighters and mine rescuers when heat must be removed from the breathing-gas stream, used to underwater divers (recreational and/or commercial) or to personnel operating in a contaminated air environment.

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254 JSC
90-1-12.07-7972 NAS9-18469
Solid-State, Oxygen-Storage Intermetallic and Alloy Development
Hydrogen Consultants, Inc.
12420 North Dumont Way
Littleton, CO 80125
John R. Riter (303-791-7972)

The traditional method of storing backup oxygen for Extravehicular Activity is as a gas, in a pair of high-pressure, spherical tanks. This represents a considerable shrapnel hazard: 0.19 MJ of compression energy (two tanks) with respect to an adiabatic expansion to atmospheric pressure from 6000 psia. This quantity of explosion energy corresponds to 66 grams of TNT. A low-pressure oxygen storage system can be summarized in the reversible reaction: solid metal oxide = solid metal + gaseous oxygen. This project will lead to the desired temperature-pressure behavior for several systems of the above type. Brittleness is one of several characteristics to be considered in this investigation of intermetallics and alloys that will take up and yield oxygen reversibly.

Potential Commercial Applications: Safe, high-density, solid-state, oxygen-storage materials would have both terrestrial and aerospace applications.

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255 MSFC
90-1-12.09-1060 NAS8-38923
Body-Mounted, Head-Up, Video Display Terminal
Tomorrowtools
6660 Highway 72 West
Huntsville, AL 35806
Ricky K. Roberson (205-830-1060)

This project will develop a body-mounted, head-up, video display terminal (VDT) capable of presenting text or graphics images to a user. This VDT will consist of two major parts of hardware, the display module and the base unit connected by a cable. The VDT uses a new display technology: a type of monocle, worn below one eye, that projects the image of a screen floating in space anywhere the user looks. This virtual screen has a resolution of 720 by 280 pixels and can display 25 lines of text with 80 characters per line. The VDT is a relevant solution to the need for a small, lightweight, output device that can be attached to the user's body. It can replace heavy, bulky notebooks in crowded spacecraft, and provides equivalent data to crew members in a more convenient, efficient manner.

Potential Commercial Applications: Applications could include aircraft moving-map displays, portable electronic books, radio pagers with text capability, portable and paperless fax machines, handheld diagnostic instruments, maintenance manuals, pocket terminals, palmtop computers, telephone displays, and video games.

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256 ARC
90-1-12.10-4164G NAS2-13349
Non-Invasive Bone Strength Measurement by a Mechanical Response Tissue Analyzer
Gait Scan, Inc.
P.O. Box 1550
Ridgewood, NJ 07451-1550
Anthony Mauriello (201-337-4164)

Bone weakening is a concern for astronauts, who now exercise in flight to prevent loss of bone in the legs and fracture on landing. Using innovative methodology, this project will design an instrument that provides direct, non-invasive, accurate, and reproducible measurements of bone stiffness, a component of bone strength. The long bones of the lower extremities of humans and larger species of animals qualifying for flight projects are the targets of analysis by this instrument, which delivers a low-frequency vibration and detects the response. Current methods for evaluating the strength of bone in vivo depend primarily on measures of the mineral content of bone by instruments that contain a radioactive source. A device that monitors the effects of exercise on bone strength, and avoids exposure to radiation, is needed for space flight. It would also have application in monitoring patients with fragile bones, or individuals engaged in sports or fitness programs. The objective of Phase I is to design the mechanical components and data-acquisition system into a single, simple system for operation and use in clinical and animal studies. The objective of Phase II would be to validate the instrument by animal and human tests, and correlate with other tests.

Potential Commercial Applications: The device would be used in research centers and in health and fitness facilities for routine monitoring of the bone-strengthening effects of exercise, diet, and other factors.

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257 ARC
90-1-12.10-9591 NAS2-13350
Advanced Avian Research Module for Microgravity Experiments
Space Hardware Optimization Technology
P.O. Box 351
Floyd Knobs, IN 47119
John C. Vellinger (812-923-9591)

The avian egg has been recognized by space biologists as an excellent, self-contained model for life-science research for more than a decade. More recently, birds have gained attention as a possible bioregenerative life-support system for Space Stations and lunar/Mars missions. Before the full potential of these avian models can be realized, an advanced, experimental testing apparatus, an innovatively designed incubator, must be developed to enable this pioneering research to move forward. This state-of-the-art experimental tool will dramatically increase the research capabilities of the space life-science community. The advanced incubator will provide maximum control of both experimental and flight variables. Phase I will investigate the feasibility of integrating several novel systems with existing, flight-proven hardware technology. The goal is to provide a unique experimental device to serve the needs of many investigators. Phase I would culminate in at least two conceptual engineering designs for the advance flight hardware which is known as the avian research module (ARM).

Potential Commercial Applications: This experimental tool for microgravity life-science research could lead to improved methods of diagnosing and treating human disease, new therapeutic products, and reduced poultry-production cost through improved hatching rates and control of microbiological contamination.

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258 KSC
90-1-12.11-0016 NAS10-11761
A General-Purpose, Biomedical Telemetry System
Konigsberg Instruments, Inc.
2000 Foothill Boulevard
Pasadena, CA 91107-3294
Eph Konigsberg (818-449-0016)

A general-purpose, miniature, biomedical telemetry system will be developed for unobtrusively monitoring a variety of physiological vital signs from a crew of individuals functioning in a hazardous environment. The design will build upon a core temperature monitoring "pill" and biotelemetry transceiver developed for the Army, as well as upon a high-speed, multichannel telemetry system. In addition to the innovative integration of these two systems, this design will seek to implement a number of additional innovative features: harnessless, external body-mounted sensors that, like the pill, telemeter their output to the transceiver; a means of transmitting voice along with physiological signs; a telemetry receiver and data-acquisition system that will plug directly into the bus of a personal computer (PC); and PC-based algorithms for display and processing of the incoming data, to provide decision aids to the base-station operation. Modularity will be stressed throughout the design, providing for the interchangeability of sensor packages. The Phase I effort will consist of a detailed design of both hardware and software, as well as bench tests of the feasibility of several key design features.

Potential Commercial Applications: The resulting system will address markets in the areas of physiological research, industrial-worker safety, medical monitoring, and athletic training.

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259 MSFC
90-1-12.12-8285 NAS8-38884
Conceptual Design of a Purpose-Built, 1-ATA Shallow-Water Diving Suit
J. M. Jenco & Associates, Inc.
P.O. Box 1855
Covington, LA 70434-1855
John M. Jenco (504-892-8285)

The aim of this project is to develop a conceptual design for a one-atmosphere diving suit. Such a suit will be suitable for use by NASA and help fulfill its need for an improved system with which to conduct EVA training exercises in a neutral buoyancy environment. The project will identify the design criteria required for support of these training activities, develop a list of necessary suit functions, survey the state of the art and evaluate it for appropriateness of technology transfer to this project, and develop a conceptual design for a working prototype. Requirements for new materials will also be identified and their suitability evaluated. Phase II development requirements will be outlined. This project will benefit NASA by providing it with more cost-effective use of training resources; in addition, the use of a less expensive training system and freedom from current personnel decompression limitations will result in expanded training time. Astronaut-trainees will benefit directly from greater comfort, increased mobility and range of motion, and greater safety through freedom from hyperbaric exposures.

Potential Commercial Applications: Applications could include subsea oil and gas development; nuclear-power-plant underwater inspection, maintenance, and repair; marine science and academic research and development; commercial diving, and liquid-tank-storage inspections.

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13: Quality Assurance, Safety, and Check-Out for Ground and Space Organizations

260 KSC
90-1-13.01-0505 NAS10-11756
Perfluorocarbons as Fire-Suppression Agents
Hughes Associates, Inc.
2730 University Blvd West, Suite 902
Wheaton, MD 20902
Philip J. Dinenno (301-949-0505)

Preliminary experimental and theoretical work has indicated that perfluorocarbons may be excellent fire-suppression agents. Because these compounds are not ozone-depleting substances, their use as Halon 1301 total-flooding, fire-suppression agents is quite promising. This Phase I effort will evaluate the performance of these compounds as fire-suppression agents and perform a feasibility study on their use as total-flooding agents to replace Halon 1301. The project will also evaluate the potential for the use of perfluorocarbons as direct "drop-in" replacements for Halon 1301 in existing systems. The project will involve small-scale testing of the suppression qualities of a range of perfluorocarbons, as well as analytical work on other aspects of the compounds related to their development as total-flooding agents.

Potential Commercial Applications: An environmentally acceptable, Halon 1301, fire-suppression agent replacement that could be manufactured commercially in the near term could have a large domestic and international market.

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261 KSC
90-1-13.03-0070A NAS10-11762
A Lightning Assessment Methodology for NASA Application
Electro Magnetic Applications, Inc.
P.O. Box 260263
Denver, CO 80226
Frederick Eriksen (303-980-0070)

A formalized lightning-assessment methodology will be developed for NASA ground systems. The methodology will be implemented in software as a smart system and will be tailored to NASA systems such as launch vehicles before launch, stored ordnance and explosives, satellites in storage or test, and computer systems. A novel derivative of the three-dimensional, finite difference solution method of Maxwell's equation, vector 3DFD, will be used to calculate fields (currents) near (on) physical structures. Several new concepts for low-level testing of structures will also be explored.

Potential Commercial Applications: An integrated assessment methodology for protecting ground systems from lightning could become an industry standard for protecting facilities in specialized, highly susceptible industries, such as explosives manufacturing, fuel refining, fertilizer production and similar manufacturing processes with potential human risk, and nuclear power production.

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262 KSC
90-1-13.03-1424 NAS10-11759
Feasibility of Numerical Thunderstorm Forecasts for Specific KSC Work Complexes
R*Scan Corporation
1200 Washington Avenue South
Minneapolis, MN 55415-1258
Walter A. Lyons (612-333-1424)

KSC needs improved forecasts of thunderstorms and their associated phenomena both for KSC as a whole and, particularly, for specific work complexes over periods of 24 hours or more. Mesoscale numerical prognostic models may offer enhanced forecast accuracy. A new, nested-grid, non-hydrostatic model (ARAMS, the advanced regional atmospheric modeling system) is believed to be capable of predicting the details of local terrain forcing that result in various thunderstorms related to the Atlantic sea breeze. These include the smaller-scale (less than 5 km) perturbations induced by rivers and islands in the KSC area. Climatological and modeling studies of one such phenomena, the Merritt Island Thunderstorm (MIT), will serve as a test of the plausibility of producing useful numerical model-generated forecasts for work complexes, on the scale of 8 km across, during the upcoming 12 to 24-hour period. Data from the summer KABLE experiment will be used. Tests will assess whether new, low-cost graphics supercomputers can provide computational power and graphics sufficient to forecast MIT-scale phenomena within operational constraints.

Potential Commercial Applications: There is a growing need for improved regional forecasting systems in military operations; electric utilities; nuclear energy, water, forest, and range management, and national weather services.

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263 MSFC
90-1-13.05-0572 NAS8-33895
Pressure-Time Flow Measurement
Windrock Associates
44 Outer Drive
Oak Ridge, TN 37830
James Kirkpatrick (615-481-0572)

Primary flowmeter calibration is a problem faced by a wide range of industries, as well as NASA. A little-known flow measurement method--the Gibson or pressure-time--will be applied to flowmeter calibration. The major advantage of the method is that it is a fundamental means of measuring mass flow that can be implemented in a closed-loop calibration facility.

Potential Commercial Applications: The introduction of a calibration method that does not require extensive facilities would be welcomed by all flowmeter users.

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264 JSC
90-1-13.06-3031 NAS9-18486
An Ultrasensitive Microprobe Detector for Surface Contamination
Potomac Photonics, Inc.
4720-E Boston Way
Lanham, MD 20706
Michael T. Duignan (301-459-3031)

This project will design, construct, and test a novel instrument for the detection of surface contamination on solid substrates. The detector will operate under ambient atmospheric conditions, will not destroy the substrate, is highly sensitive, and provides real-time information. Potential sensitivity of the device is on the order of 10 ng per square cm, (nearly monolayer detectability). The device could be miniaturized and may be capable of remote sensing in otherwise inaccessible places, such as inside long stretches of bent tubing. The instrument uses a new opto-acoustic technique to sense laser-induced, photothermal desorption of adsorbate (or contaminant) from a surface. An ultraviolet waveguide excimer laser is used for laser-induced desorption; a helium-neon probe senses the desorption event. The instrument could be transportable, is inherently simple, and should find many uses in manufacturing, electronics and semiconductor processing, and environmental testing.

Potential Commercial Applications: Applications in the electronics industry are as quality-control aids in soldering, bonding, and sealing operations, as well as in semiconductor processes. Manufacturing uses include monitoring machined parts for residual lubricants and solvents. The device could also be used to detect toxins, such as pesticide residues and PCBs.

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265 KSC
90-1-13.08-9450 NAS10-11755
A Rocket-Engine Leak-Detection System for Hydrogen and Oxygen
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Michael M. Carrabba (617-769-9450)

The goal of this project is to develop a real-time leak-detection and -monitoring system for hydrogen, oxygen, and nitrogen in STS applications. The objective of Phase I is to develop and test several methodologies for the qualitative and quantitative measurement of hydrogen, oxygen, and nitrogen in the STS environment, based on the use of a direct spectroscopic technique (Raman spectroscopy). The major advantages of a Raman-based system include real-time response, quantitative and qualitative analysis capabilities, simultaneous multicomponent detection, no moving parts, low detection limits (less than 1 ppm), and intrinsic safety. Since Raman techniques are highly adaptable to fiber optics, an integrated network of reliable, selective, low-maintenance sensors can be developed that responds rapidly and provides ample warning time before hydrogen or oxygen concentrations approach dangerous levels. The network would also pinpont the location of the leak. The objective of the Phase II program will be to develop, field test, and deliver both a lightweight (less than 2 lbs), vibration-resistant, self-contained unit and a centrally based, integrated network.

Potential Commercial Applications: Applications for the Raman monitoring instrument exist in water pollution, forensics, and industrial process control.

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14: Satellite and Space Systems Communications

266 GSFC
90-1-14.02-0755 NAS5-31393
External Phase or Amplitude Modulator for Lasers
Lightwave Electronics Corporation
1161 San Antonio Road
Mountain View, CA 94043
Emily Cheng (415-962-0755)

This project will develop a small, lightweight, external modulator that can impress either phase or amplitude modulation on a Nd:YAG laser output. The modulator will take advantage of the very stable, electronically tunable, single-frequency output of the diode-pumped Nd:YAG nonplanar ring oscillators by using resonance-enhancement properties to reduce the modulation voltage requirements. It will be capable of handling an average optical power in excess of 1 watt at modulation frequencies from 100 kHz to over 1 GHz with negligible insertion loss.

Potential Commercial Applications: Versions of this system operating at 1.32 microns and coupled to single-mode optical fiber will be useful for terrestrial fiber-optic communication.

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267 GSFC
90-1-14.02-2299 NAS5-31395
A Diode-Pumped Laser for Space-Based Communications
Schwartz Electro-Optics, Inc.
45 Winthrop Street
Concord, MA 01742
James Harrison (508-371-2299)

A high-power, single-frequency laser based on a unique, modular, neodymium (Nd) gain-element that is pumped by an array of semiconductor diode lasers will be developed. This device would be capable of driving a compact, multiwatt laser transmitter in a space-based communication system. Output powers in excess of 10 watts could be generated by including multiple gain elements in a single laser resonator. The primary goals of the Phase I effort are design and construction of a prototype gain module including a 10-watts, GaAlAs laser array and demonstration of a single-frequency, Nd:YAG laser built around the prototype module and capable of generating approximately 2 watts at 1064 nm.

Potential Commercial Applications: Single-frequency, high-power, diode-pumped Nd lasers will find immediate application as master oscillators, transmitters, and receivers for coherent lidar and communications systems. With second harmonic generation, they will provide an all-solid-state replacement for air-cooled and small-frame argon-ion lasers.

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268 JPL
90-1-14.03-6000 NAS7-1119
Pseudomorphic HEMTS for Millimeter Wave Communications
Spire Corporation
Patriots Park
Bedford, MA 01730
Patricia Sekula-Moise (617-275-6000)

Advances in scientific instrumentation used in deep-space missions have generated a need for high data-transmission rates to Earth. It may be economically feasible to use the Ka band (27-40 GHz) for up- and down-linking; thus development of monolithic microwave integrated-circuit phased array distribution systems for millimeter wavelengths is demanded. The pseudomorphic, high-electron-mobility transistor (HEMT) is unequivocally the best candidate for high-power, high-efficiency applications from 10-100 GHz. Its superior low-noise performance provides the opportunity for integration of both high-power and low-noise devices on the same chip without compromising the performance of either component. The innovation explored in this project is an inverted, double, heterojunction HEMT with pulse-doped donor and pseudomorphic channel layers to be grown by MOCVD, the deposition technique of choice for high-quality production capability. The Phase I project will demonstrate feasibility of concept; Phase II will result in an optimized structure suitable for production.

Potential Commercial Applications: This project could establish technology to produce high-power, high-efficiency HEMT devices that may be more radiation hard than conventional bulk-doped materials. Commercialization would be pursued through the sale of MOCVD system-technology transfer packages and custom-grown epitaxial wafers.

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269 JPL
90-1-14.04-8000 NAS7-1128
GaAs MMIC Sampling Mixer for Frequency Conversion
Pacific Monolothics, Inc.
245 Santa Ana Court
Sunnyvale, CA 94086
Fazal Ali (408-732-8000)

High-speed, digital-signal processing and detection techniques to downconvert and process Ka-Ku-X and S-band signals are needed. A GaAs integrated-circuit version of a sampling mixer will be investigated for this purpose. A circuit configuration will be defined for S- and X-band chips, and specifications necessary for the development of the chip during a follow-on phase will be defined. Circuit implications and design options for extending the work to Ku- and Ka-band regions will be studied.

Potential Commercial Applications: A GaAs MMIC sampling mixer will find applications in commercial communication circuits such as GPS receivers, cellular telephones, and wireless LAN.

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270 LeRC
90-1-14.05-0497 NAS3-25925
Optical Multiple Access Techniques for On-Board Routing
Mendez R&D Associates
P.O. Box 2756
El Segundo, CA 90245
Antonio J. Mendez (213-640-0497)

Temporal and spectral code-division, multiple access (CDMA) technologies have ideal properties for satellite on-board routing: they lend themselves to asynchronous broadcast modes with no overhead or latency. Also, when the network is initially overdesigned (in the sense of having more codes than users), its excess capacity can be used for redundancy (reliability) or for live insertion of new users without a change of software or protocol. The problem with temporal and spectral CDMA is that, for many users (>10) and high data rates (>50 Mb/s), complex, expensive laser sources of very short pulse width (<<1 ns) are required. Logical alternatives to CDMA are temporal/spatial hybrids (parallel bus analogs of the temporal CDMA) and sonar matrices. These alternatives reduce the cost and complexity of the active components; at the same time, they increase the passive components in the photonic network. This project will evaluate temporal, spectral, and hybrid/sonar matrices schemes for satellite on-board routing. Criteria will include users, data rate, redundancy, live insertion (new or backup users), cost, complexity, and compatibility with reconfigurability by means of knowledge-based systems. The end product will be specifications and designs for Phase II.

Potential Commercial Applications: Satellite crosslinks; advanced-generation, local-area networks; secure communication; optical backplane buses; and computer networks are all prospective applications.

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271 LeRC
90-1-14.05-0703 NAS3-25923
A Low-Power, Heater-Cathode System for High-Frequency Space Communications
FDE Associates
Rural Route 1, Box 988
Beaverton, OR 97007-9719
Bernard Vancil (503-628-0703)

Because of new technology, it is now possible to offer higher electron-beam densities and longer cathode life at lower heater powers then ever before. This is a significant development for high-frequency space communications, Ka band and above; in this area, the limiting factor on microwave power and efficiency has

been the cathode loading and size. A very small, rugged, heater-cathode system that will exploit these new technologies will be developed. It will produce up to 2 amps per square centimeter of current density, live for at least 30,000 hours, and consume less than 1/2 w of heater power. The device will employ the new scandate oxide cathode, as well as a cathophoretically coated and darkened heater that is now available in very small sizes. The ability to extrude seamless tubing at wall thickness not previously available will provide maximum thermal isolation of the cathode-support structure.

Potential Commercial Applications: This tecnology may be used in aircraft-to-satellite communications, in traveling wave tubes and klystrons, and in high-performance cathode-ray tubes for portable oscilloscopes and television sets.

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272 LeRC
90-1-14.05-3907 NAS3-25939
Ka-Band, High-Efficiency Power MMIC
Schellenberg Associates
18091 Fieldbury Lane
Huntington Beach, CA 92647
James M. Schellenberg (714-847-3907)

This project will develop a 500 mw MMIC operating at 35 GHz with a chip-supply voltage of 28 volts and a power-added efficiency of more than 40 percent. These results will be achieved by employing two circuit innovations: a series-cell configuration and an on-chip, high-efficiency combiner. The unique series-cell configuration results in a high-chip-bias voltage (28 volts) because the FET cells are biased in series instead of in parallel, as with conventional ICs. This greatly increases the efficiency of the system employing the chips and even permits the IC to operate directly from the spacecraft bus, thereby eliminating the losses in the power-conditioning circuitry (DC-to-DC converter and regulator). Further, the high chip efficiency is achieved by employing an on-chip, low-loss, cell-combining circuit that simultaneously combines and matches the FET cells with a combining efficiency of 95 percent. This work will have a major impact on the way that high-efficiency power MMICs are designed in the future. In particular, this work could be extremely important for satellite- and spacecraft-based communication links, for which prime power consumption is a major concern.

Potential Commercial Applications: This product could be used in satellite/spacecraft communication links; airborne, active-phased array radar; and any Ka-band application requiring high-efficiency power.

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273 JPL
90-1-14.06-8585 NAS7-1127
Growth of Nd:YVO_4 Crystals for Laser Technology
Photon Physics, Inc.
3175 Penobscot Building
Detroit, MI 48226
Ontario H. Nestor (313-962-8585)

Space communications at optical frequencies demand the development of laser crystals that exhibit high power-conversion efficiency. Growth of Nd:YVO_4 single crystals by an innovative, laser pedestal growth method will be explored. Earlier published work has clearly revealed that these crystals exhibit a very high slope efficiency, less than 50 percent optical efficiency, and 12 percent electrical-to-optical conversion efficiency. Due to the high melting point of yttrium vanadate (about 1825°C), conventional crystal-growth techniques yield crystals with numerous defects. The innovative technique used in this project involves growing these crystals with a laser pedestal growth method in which only a small section of the material is melted with a carbon dioxide laser source coupled with a few mirrors to focus the bean at the crystal-liquid interface. The chief advantages of this method are that the growth process is relatively fast and that the crystals are grown without any container. As a result, the crystals are free of any contamination. The goal of Phase I will be to establish the optimum conditions for the growth of these crystals in relatively small size. During Phase II, extensive work would be undertaken to grow large crystals and characterize them thoroughly.

Potential Commercial Applications: Nd:YVO_4 crystals would be useful in the development of lasers for satellite communications, military communications, medical electronics, magneto-optical recording, robotics, micromachining, and microsurgery.

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274 LeRC
90-1-14.07-4605 NAS3-25924
Feedback, Pseudomorphic HEMT, Low-Noise, Amplifiers for Low-Cost Receivers
Pacific Coast Engineering
P.O. Box 1956
Thousand Oaks, CA 91358
Larry J. Nevin (805-371-4605)

This project addresses the combination of new device technology, detailed device modeling, and new circuit techniques for small, earth-terminal, low-cost, Ka-band receivers. The development of both GaAa and silicon-bipolar MMICs are key to cost improvement in these systems, but hybrid solutions for selected components can still be cost effective when there is a performance benefit. The microwave device and related assembly costs are only a part of the total, which includes significant mechanical costs and the cost of an input isolator. In this project, a combination of device and circuit design will focus on the simplification of microwave hardware to retain the high performance levels required of a 20-GHz, low-noise receiver, while eliminating the need for an input isolator normally used to provide input impedance match. Specifically, 0.1-micron-gate-length, pseudomorphic HEMTs, which offer superior noise and gain performance, will be used in feedback circuit designs that provide simultaneous noise- and signal-match through feedback techniques.

Potential Commercial Applications: Applications would be in 20-GHz, low-noise receivers for satellite and terrestrial communication systems.

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275 JPL
90-1-14.08-0700 NAS7-1141
Fast, Reliable, Electro-Optic Modulation Technology
Laser Power Research
12777 High Bluff Drive
San Diego, CA 92130
Bradley N. Mells (619-755-0700)

A versatile, high-voltage pulse generator that has been designed for Pockels-cell driver applications will be developed. The device is capable of producing fast rise and fall times, and provides for high repetition frequency operation. The novel system is based on a hybrid technology incorporating a pair of planar triodes as the high-voltage switching elements, which are driven by relatively low-voltage MOSFET devices. Planar triodes are highly reliable tubes capable of switching high voltages on a nanosecond time scale. These vacuum tubes offer important advantages over high-voltage transistors, considering the limitations of current MOSFET technology. Through incorporating two tubes, fast rise and fall times can be achieved with the added capability for arbitrary temporal positioning of the rising and falling edges of the high-voltage pulse. Thus, the system is suitable for pulse width modulation applications in communications, as well as in a wide range of commercial laser applications requiring fast pulse selection and control.

Potential Commercial Applications: Applications of the device will include Q-switching, mode-locked laser pulse selection, regenerative amplification, pulse compression, and high-speed, laser-beam control systems. The technology also has important applications in pulse width modulation coding of high-power laser beams for long-range communications.

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15: Materials Processing, Micro-Gravity, and Commercial Applications in Space

276 LeRC
90-1-15.01-0101 NAS3-26132
Computational Environment for Microgravity Materials-Processing Simulations
Nektonics, Inc.
875 Main Street
Cambridge, MA 02139
Lee-Wing Ho (617-868-0101)

Accurate numerical simulations should provide a powerful tool for planning meaningful experiments on future space missions. A comprehensive, general-purpose tool or simulation of space-based materials processing problems will be developed using the NEKTON spectral-element, general-geometry flow code. This tool will permit the optimization of configurations and parameters required for space applications. In particular, the floating-zone melt problem, which is critical for economically and reproducibly increasing the yield of high-quality crystals, will be modeled. Such modeling will involve enhancing the NEKTON code to handle Marangoni convection due to variable surface tension, accurate implementation of triple-point conditions, radiative-heat transfer, and volumetric heating.

Potential Commercial Applications: For materials processing in space to succeed, computational simulation methods are required to achieve optimal experimental configurations and parameter choices, because of the limited opportunity to perform preliminary experiments in a microgravity environment.

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277 MSFC
90-1-15.01-0760 NAS8-38913
Controlled Nucleation of Protein-Crystal Growth
Crystal Research
1441 Sunnyside Terrace
San Pedro, CA 90732
Paul J. Sclichta (213-831-0760)

To support the growth of protein crystals in microgravity, this project will improve the control of nucleation by the use of epitaxial substrates, instead of seed crystals or spontaneous nucleation, to greatly simplify flight apparatus and increase experiment reliability. Specifically, this project will develop, experimentally verify, and apply a computer program for rapidly finding all possible expitaxial substrates for any given protein crystal. Phase I tasks will include establishment of the validity of the search algorithm, development and testing of a preliminary version of the search program and predictions of new cases, and experimental verification of these predictions. The ultimate goal is to provide epitaxial substrates for all microgravity protein-crystal growth experiments.

Potential Commercial Applications: There will be a reasonable market for the program as a software package, for consultation service to those seeking new epitaxial substrates, and for producing and marketing substrates in R&D quantities for the electronics and optical industries.

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278 MSFC
90-1-15.01-6551 NAS8-38901
Variable-Temperature-Gradient, Heat-Pipe Furnace Element
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
John R. Hartenstine (717-569-6551)

Beginning in the 1970s numerous experimental studies were conducted in space in near-zero-G environments to study the effects of crystal growth in the absence of gravity. These tests were conducted aboard Skylab and during the Apollo-Soyuz Test Project. Even though the results proved the advantages of materials processing in space, limitations in the

equipment, such as the processing furnace, were realized. A more versatile, higher-temperature, variable-gradient furnace is required for future space ventures. The crystal-growing furnace must have a uniform temperature profile within the work area. The profile must be variable without physically altering the furnace system. The goal of this project is to design and demonstrate a variable-temperature-gradient heat pipe to be used in a microgravity environment. The variable-temperature profile will be created by the diffusion of the heat-pipe working fluid into a non-condensible gas. This concept will provide a wide range of uniform temperature profiles and, at the same time, minimize mass and power consumption. The Phase I work effort will include the design, fabrication, and testing of a demonstration-model furnace element to prove feasibility. Phase II would include the fabrication and extensive testing of a full-scale model.

Potential Commercial Applications: The variable-temperature-gradient, heat-pipe furnace element could offer significant advances in materials processing on earth or in space. This type of furnace element could be used for Czochralski and Bridgeman crystal-growth methods.

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279 LeRC
90-1-15.01-8086 NAS3-25979
Comprehensive Accelerometer, Data-Analysis Software
Payload Systems, Inc.
276 Third Street
Cambridge, MA 02142-1112
Anthony Arrott (617-868-8086)

Definition and design of software to facilitate post-flight characterization of the acceleration environment of microgravity experiments will be developed. Algorithms will be defined to analyze acceleration data, transformed into the experiment's coordinate system, using time and frequency domain techniques (transient analysis and power spectral density, respectively). A new, combined time-and-frequency domain analytical tool—wavelet transforms—will be developed, as will methods for quickly scanning data sets to extract interesting portions. Methods for efficient data handling and storage are also to be addressed with the design of digital filtering and decimation schemes to reduce dataset bandwidth and size. The use of commercially available programs that fulfill some of the requirements of this system will be emphasized for cost effectiveness. Platform and input/output media compatibility will be specified to meet the needs of the microgravity sciences community, as determined by a poll of investigators.

Potential Commercial Applications: Microgravity research and R&D for the commercialization of space requires an accurate and useful characterization of the microgravity environment. Software developed under subsequent phases of this SBIR project would be made into a commercial product for microgravity investigators, and more generally, the accelerometer community, so that this acceleration characterization can be carried out easily.

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280 LeRC
90-1-15.02-3800 NAS3-25978
Spacecraft Multiphase Flow Experiments
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Paul H. Rothe (603-643-3800)

Phase I of this project will define multiphase flow experiments critical to ensuring the reliable operation of spacecraft multiphase flow systems for NASA missions. The objectives of this work are to design critical experiments to use effectively the facilities at NASA/LeRC in Phase II, and to design experiments to be performed in space thereafter. In this way, the science of microgravity multiphase flow will be advanced, and the technology risks of multiphase systems for thermal management, power, and other spacecraft systems will be anticipated.

Potential Commercial Applications: This project could lead to the supply of equipment and services for NASA, DOD, and their prime contractors in spacecraft development activities.

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Appendix A: Description of the SBIR Program

Small Business Innovation Research

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 bylaws 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 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 1989, $53 millions was provided to the NASA SBIR program. Including the amounts set aside for FY 1990 and 1991, the NASA SBIR program funding for all years of the program to date amounts to more than $350 millions for 1,513 Phase I and 632 Phase II awards. 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 2,568 in 1991. 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 762 firms in 42 states, the District of Columbia and Puerto Rico. Approximately 17 percent of the firms submitting proposals have received Phase I awards, and about 48 percent of those firms have received Phase II continuations.

Appendix B: 1990 Topics and Subtopics

01 Aeronautical Propulsion and Power

- 01.01 Internal Fluid Mechanics for Aeronautical Propulsion Systems
- 01.02 Aeronautical Propulsion System Components
- 01.03 Aeronautical Propulsion System Instrumentation, Sensors and Controls
- 01.04 Novel Aeronautical Propulsion Concepts

02 Aerodynamics and Acoustics

- 02.01 Computational Fluid Dynamics
- 02.02 Theoretical Aerodynamics and Viscous Flow
- 02.03 Hypersonic Vehicle Aerothermodynamics
- 02.04 Rarefied Gas Dynamics
- 02.05 Plume-Induced Effects on Launch and Orbital Vehicles
- 02.06 Configurational Aerodynamics Including Vortices
- 02.07 Rotorcraft Aerodynamics and Dynamics
- 02.08 Wind Tunnel Design and Experimental Techniques
- 02.09 Wind Tunnel Instrumentation
- 02.10 Aircraft Noise Prediction and Reduction
- 02.11 Propulsion Noise Reduction

03 Aircraft Systems, Subsystems, and Operations

- 03.01 Aircraft Ice Protection Systems
- 03.02 Aircraft Severe 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 Systems
- 03.10 Development, Testing, and Verification of Flight Critical Systems
- 03.11 Integrated Aerospace Vehicle Flight Characteristics Simulation

04 Materials and Structures

- 04.01 High Temperature Composite Materials Technology for Aeropropulsion Applications
- 04.02 Processing of High Temperature Composite Materials for Aeropropulsion Systems
- 04.03 Improved Fibers for High Temperature Composites for Power and Propulsion
- 04.04 Environment-Resistant Alloys for Launch Vehicle and Space Propulsion Systems
- 04.05 Computational Structural Methods for Aeropropulsion Applications
- 04.06 Composite Materials for Aerostructures and Space Applications
- 04.07 Light Alloy Metallics for Airframe Structures
- 04.08 Welding Technology
- 04.09 Nondestructive Evaluation Technology to Characterize Material Properties
- 04.10 Bond Strength of Thermal Sprayed Coatings
- 04.11 Special-Purpose Materials, Processes and Testing for Space Flight Applications
- 04.12 Thermal Protection Materials and Systems
- 04.13 Adaptive Deployable Structures
- 04.14 Spacecraft Structures and Mechanisms
- 04.15 High Temperature Superconductors for Aerospace Applications
- 04.16 Lunar Materials Utilization

05 Teleoperators and Robotics

- 05.01 Large Scale Telerobotic Systems
- 05.02 Telerobotic and Biomechanical System Software Development
- 05.03 Telerobotic Electro/Mechanical Systems
- 05.04 Space Based Manipulator Mechanisms and Controls
- 05.05 Artificial Intelligence for Space Station Applications
- 05.06 Supervised Autonomous Servicing Technology
- 05.07 Space Mechanisms
- 05.08 Robotic Adaptive Grasping and Manipulation Systems
- 05.09 Mission Support Flight Robotics

06 Computer Sciences and Applications

- 06.01 Engineering Computer Science
- 06.02 Software Development and Maintenance
- 06.03 Reliable Software Development
- 06.04 Knowledge-Based Systems Technologies for Aerospace Applications
- 06.05 Software Systems for Mission Planning and Flight Control
- 06.06 Computer Sciences in Computational Physics
- 06.07 Large Multiprocessor Database Technology
- 06.08 Space Flight Data Systems
- 06.09 Shuttle and Payload Ground Processing Systems
- 06.10 Optical Processing Technology
- 06.11 Analysis and Synthesis of Engineering Systems

07 Information Systems and Data Handling

07.01 Focal-Plane Image Processing
07.02 Earth Observing System Data Technologies
07.03 Simulation Model for Multispectral Sensors and Imaging Systems
07.04 Spatial Data Management and Geographic Information System
07.05 Geographic Information System Software Development
07.06 Information Processing Technology and Integrated Data Systems
07.07 Advanced Remote Sensing Database Technology
07.08 Heterogeneous Distributed Database Management
07.09 Spacecraft On-Board Information Extraction
07.10 Computational Libraries for Massively Parallel Computing Systems
07.11 Planetary Data System Educational Software

08 Instrumentation and Sensors

08.01 Earth Atmosphere Sensing and Topographic Measurements from Space
08.02 Low-Cost, High-Resolution, Airborne, Remote Sensing Instrumentation for Earth Sciences
08.03 Sensors for Aerosol and Cloud Studies
08.04 Laser Polarization Profiling
08.05 Earth Atmospheric LIDAR Remote Sensing
08.06 Tunable Solid-State Lasers, Detectors and LIDAR Subsystems
08.07 Earth Observing Sensor Development for Geostationary Orbit
08.08 A Cold Coronagraph for Planetary Observations
08.09 Detectors and Detector Arrays
08.10 Laser Heterodyne Technology
08.11 Infrared Technology for Astronomical Applications
08.12 Infrared Spectroscopy with Detector Arrays
08.13 High-Operating-Temperature Infrared Detector Arrays
08.14 Submillimeter Antennas, Radiometers and Spectrometers
08.15 High-Field Vector Helium Magnetometer for Space Applications
08.16 Instrument Technology for Exobiology
08.17 Instrumentation for Geology
08.18 Oceanographic Instrumentation
08.19 Efficient Production of All-Metal Cryogenic Telescopes
08.20 Optical Fabrication and Metrology
08.21 Spacecraft Contamination Monitoring
08.22 High Resolution Charged Particle Instrumentation
08.23 Detectors for Gamma Ray Astronomy
08.24 Gamma Ray and X-Ray Spectroscopy
08.25 Underwater Position Three Dimensional Measuring System
08.26 Non-Invasive Fluid Measuring Instrument

09 Spacecraft Systems and Subsystems

09.01 Control of Large Space Structures
09.02 Guidance, Navigation and Control of Advanced Space Transportation Systems
09.03 Digital Processor for an Earth Horizon Scanner Attitude Control System
09.04 Spacecraft Flight Dynamics
09.05 Tracking System for STS, Space Station, Lunar and Mars Missions, and Robotics
09.06 Space Station Crew Workstation Displays and Controls
09.07 Spacecraft Data Transfer Using Monolithic Microwave Integrated Circuits
09.08 Sensor Applications of Monolithic Microwave Integrated Circuits
09.09 Cyrogenic Refrigeration Systems
09.10 Thermal Control for Unmanned Spacecraft
09.11 Thermal Management Systems for Manned Lunar and Planetary Missions
09.12 Manned Spacecraft Thermal Systems
09.13 Fluid Management, Leak Detection, and Fire Suppressants for Manned Missions
09.14 Spacecraft Plasma Environment Forecasting
09.15 Technologies for Long Duration Scientific Balloons

10 Space Power

10.01 Space Energy Conversion Systems
10.02 Optical Coating for Aerospace Solar Cell Cover-Glasses
10.03 Thermal-to-Electric Conversion Technology
10.04 Photovoltaic-Laser Energy Converters
10.05 Space Electrochemical Storage Systems
10.06 High Specific Energy and Long Life Batteries
10.07 Portable Rechargeable Energy Storage for Space Station Applications
10.08 Space Power Management and Distribution
10.09 Electrical Power Control and Distribution Subsystems
10.10 Flexible Magnetic Circuit Components for Space Power

11 Space Propulsion

11.01 Propulsion System Combustion Processes
11.02 Liquid Engine Internal Flow Dynamics
11.03 Solid Rocket Motor Technology
11.04 Space Propulsion Systems for Orbit-to-Orbit and Injection/Transfer Vehicles
11.05 Unconventional Rocket Engines for Altitude Compensation and Throttling
11.06 Low Reynolds Number and Plume Flows
11.07 Diagnostics for Chemical Rocket Engines
11.08 Fiber Optic Measurement Technology for Cyrogenic Liquid Propulsion Systems
11.09 Propulsion Ground Testing Technology

12 Human Habitability and Biology in Space

- 12.01 Medical Sciences for Manned Space Programs
- 12.02 Biomedical and Environmental Health Support for Manned Space Programs
- 12.03 Regenerative Life Support: Air, Water and Waste Management
- 12.04 Bioregenerative Food Production
- 12.05 Human Factors for Space Crews
- 12.06 Intra-Vehicular Systems for Space Crews
- 12.07 Extra-Vehicular Activity
- 12.08 Human Factors for Long Duration Space Missions
- 12.09 Man-Space Systems Integration
- 12.10 Life Sciences Spaceflight Technology
- 12.11 Miniature Biomedical Telemetry Instrument
- 12.12 One-Atmosphere-Pressure Underwater Suit

13 Quality Assurance, Safety, and Check-Out for Ground and Space Operations

- 13.01 Halon Replacement for Use in Electronic Facility Fire Protection Systems
- 13.02 Portable Inductive Welder with Integral Weld Verification
- 13.03 Launch and Ground Weather Forecasting
- 13.04 Fluids and Fluid Systems Components
- 13.05 Flowmeter Test and Calibration
- 13.06 Test Facility Instrumentation and Safety Devices
- 13.07 Quality Assurance of Very Large Scale Integrated Circuits
- 13.08 Nondestructive Evaluation Inspection Techniques for Launch Readiness Verification

14 Satellite and Space Systems Communications

- 14.01 Communications for Manned Space Systems
- 14.02 Advanced Data Relay Satellite Systems
- 14.03 Millimeter Wave Deep Space Communications Components
- 14.04 Spacecraft Telecommunications Systems
- 14.05 Advanced Satellite Communications Systems
- 14.06 Optical Communications for Deep Space
- 14.07 Low Cost Ka-Band Ground Terminals
- 14.08 Laser Position Modulators for Optical Communications

15 Materials Processing, Microgravity, and Commercial Applications in Space

- 15.01 Materials Processing in Space
- 15.02 Microgravity Science, Technology and Engineering Experiments
- 15.03 Chemical Vapor Deposition Analysis and Modeling Tools

Appendix C: Index of 1990 Phase I Projects By State

Appendix D: Index of Participating Companies

- A -

- B -

Bend Research, Inc.
Bend, OR 97701-8599
242: Reverso-Osmosis Membranes for Removal of Low-Molecular-Weight Organics from Water
243: A Membrane-Based Atmosphere-Control Subsystem
245: A Membrane-Based Subsystem for Water-Vapor Recovery from Plant-Growth Chambers

Berkeley Research Associates, Inc.
Berkeley, CA 94701
180: High-Spatial-Resolution E x B Magnetic-Field Probe

Betac Corporation
San Antonio, TX 78227
113: Digital Video-Interactive-Based Intelligent Computer-Assisted Training/Mission Planning System

Biophotonics, Inc.
Greenfield, WI 53220
236: Chemiluminescent Deoxyoligonucleotide Probes for the Rapid Detection of Bacteria

Biotronics Technologies, Inc.
Wauwatosa, WI 53226
246: An On-Line Microbiological Analyzer

Bonneville Scientific, Inc.
Salt Lake City, UT 84105
098: Self-Contained Miniature Dexterous Hand

Boston Advanced Technologies, Inc.
Boston, MA 02215
237: Non-Invasive Blood Analysis During Manned Space Flight

Boundary Technologies, Inc.
Buffalo Grove, IL 60089
221: Hermetically Sealed Aluminum-Electrolytic Capacitor

- C -

CFD Research Corporation
Huntsville, AL 35805
002: A Probability Density Function Method for Turbulent Reacting Flows
007: Integration of Combustor Aerodynamics and Fuel Spray to Increase Turndown Fuel-Air Ratio in Small Gas-Turbine Combustors

CSA Engineering, Inc.
Palo Alto, CA 94306-4682
071: Magnetic Energy Absorber for Docking-Impact Attenuation

Cambridge Hydrodynamics, Inc.
Princeton, NJ 08542
001: Advanced Turbomachinery CFD Design and Analysis Program
222: Large-Eddy Simulation of Combustion in Liquid-Fuel Rockets

Cape Cod Research, Inc.
Buzzards Bay, MA 02532
203: Solid-Solid, Phase-Change Materials for Low-Temperature Applications

Caroware, Inc.
Bethesda, MD 20827
179: Environment for Spacecraft Contamination Assessment

Ceracon, Inc.
Sacramento, CA 95834
058: Novel Higher Temperature Aluminum Alloys by Rapid Consolidation of Glassy Structures

Ceramphysics, Inc.
Westerville, OH 43081
156: Capacitor Components for 2 K Detectors
197: Improved Regenerator Materials for Cryocoolers

Charles River Analytics, Inc.
Cambridge, MA 02138
089: A Hybrid Neural Network and Expert System Environment
108: A Testing Methodology for High Reliability Software

Chimera Research
Del Rio, TX 78842-1777
011: Solution-Adaptive Gridding within the Chimera Grid Scheme

Clever Fellows Innovation Consortium Inc
Melrose, NY 12121
209: A Robust, Manufacturable Alternator and Suspension for Free-Piston Stirling Engines

Coherent Systems, Inc.
Houston, TX 77058
234: A Hand-Held Medical Diagnostic Ultrasound B-Mode Scanner with Doppler

Composite Applications & Procedures
Simi Valley, CA 93065
199: Spacecraft Thermal Management Using Metal-Matrix Composite

Computer Applications Service
Signal Mountain, TN 37377
143: Neural Networks for Real-Time Data Evaluation in Remote-Sensing Instrumentation

Concept Development Associates (CDA)
Manhattan Beach, CA 90266-6017
144: Portable Imaging Spectroradiometer for Ground-Truth and Earth Remote Sensing

Conductus, Inc.
Sunnyvale, CA 94086
073: Large-Area, High-Temperature Superconducting Thin Films

Convolve, Inc.
New York, NY 10038
084: A Method of Improving the Dynamic Performance of Telerobotics Systems

Covalent Associates, Inc.
Woburn, MA 01801
214: Overcharge Protection Additives for Rechargeable Lithium Batteries

Creare, Inc.
Hanover, NH 03755
202: High-Capacity, Heat-Pipe Radiator
206: Cryogenic-Fluid Management for Spacecraft
219: Passively Cooled High-Temperature Superconductive Bus for Space Power Systems
280: Spacecraft Multiphase Flow Experiments

Crystal Research
San Pedro, CA 90732
181: Growth of Lead Carbonate Scintillator Crystals
277: Controlled Nucleation of Protein-Crystal Growth

Cybernet Systems Corporation
Ann Arbor, MI 48105
093: Intelligent Robot/Sensor Operations Planning Systems
100: Robotic Guidance Systems Using Specialized and Generalized Targets
138: A Computer Based Information Management System for JPL Image Data in Education

- D -

DNA Sciences
Houston, TX 77054
239: Quantitation of Radiation Effects on Human Cells

Daedalus Enterprises, Inc.
Ann Arbor, MI 48106
189: Laboratory Demonstration of Innovative, Compact Three-Dimensional Imaging Sensor
230: High-Frame-Rate, Imaging Spectrometer for Rocket Plume Diagnostics

Deacon Research
Palo Alto, CA 94303
032: In-Flight Flow-Velocity Sensor

Deep Ocean Engineering, Inc.
San Leandro, CA 94577
251: An Underwater Remotely Operated Vehicle to Test Enhanced Human Interfaces

Delta Data Systems, Inc.
Picayune, MS 39466
131: The Display and Analysis of Variable Resolution Spatial Data in a GIS Environment

Delta G Corporation
Sun Valley, CA 91352
044: Method for Producing Ultra Pure Titanium Aluminide Wire for Arc-Spray Feed
046: High-Performance, Textile Grade, Micro-Laminate Fibers

Deposition Sciences, Inc.
Santa Rosa, CA 95401
210: Improved Solar Cell Cover-Glasses Coated by Low-Pressure, Chemical Vapor Deposition

Detector Technology, Inc.
Brookfield, MA 01506
158: The Manufacture of High-Gain, Sheared MCPs Through an Innovative Boule Design

Dimension Technologies, Inc.
Rochester, NY 14607
115: A Full-Resolution, Autostereoscopic Display with Hologram-Like "Look Around" with a Wide Viewing Zone

Duncan Technologies, Inc.
Newcastle, CA 95658
231: An Ultra-High Resolution Plume Anomalous Specie Detection System for SSME Engine Pre-Flight Testing

- E -

EIC Laboratories, Inc.
Norwood, MA 02062
077: High-T_c Superconducting Composites for Interconnects to Cryogenic Equipment
215: New Electrolytes for Secondary Li/TiS2 Cells
265: A Rocket Engine Leak Detection System for Hydrogen and Oxygen

EMEC Consultants
Export, PA 15632
079: Novel Approach to the Electrolysis of Oxides

ENSCO, Inc.
Springfield, VA 22151-2388
121: Automated Operations and Maintenance Instructions System

Eidetics International, Inc.
Torrance, CA 90505
021: A Multiple Component Force and Moment Balance for Water Tunnel Applications
022: Aerodynamic Control of Aircraft Using Miniature, Rotatable Nose-Boom Strakes

Electric Propulsion Laboratory, Inc.
Tehachapi, CA 93561
059: Low Flow Arc-Head Vacuum Welding

Electro Magnetic Applications, Inc.
Denver, CO 80226-0263
261: A Lightning Assessment Methodology for NASA Application

Electronic Imagery, Inc.
Delray Beach, FL 33445
252: High Definition, Full-Color, Virtual-Image Processing

Energy Innovations, Inc.
Houston, TX 77054
218: Materials and Methods of Construction for Thermovoltaic Cells and Batteries

Energy Research Corporation
Danbury, CT 06813
217: Evaluation of Zinc-Oxygen Cells with Advanced Components

Engineering Design & Systems
Federal Way, WA 98003
092: A Close-Up Fiber Optic Remote Viewing System for Robotic and Teleoperated Systems

Engineering Systems Simulation
Cerritos, CA 90701-7265
040: A Finite-Element, Heat-Transfer Analysis System for Simulation of Flight Vehicles

Erdas, Inc.
Atlanta, GA 30329
130: An Expert System Interface for Knowledge-Based Image Classification and GIS Modeling

Essex Corporation
Orlando, FL 32803
233: A Portable Dark Focus Instrument

Exos, Inc.
Burlington, MA 01803
096: An Exoskeleton Arm Master for Robot Control
249: A Force-Feedback, Anthropomorphic, Teleoperation Input Device for Control of Robot Hands

- F -

FDE Associates
Beaverton, OR 97007-9719
271: A Low Power Heater-Cathode System for High Frequency Space Communications

Femtometrics
Costa Mesa, CA 92627
146: In-Situ Chemical Identification of Size-Segregated High-Altitude Aerosol Particles
169: Continuous Real-Time Monitoring of Size and Mass of Particles Generated by Gas-Grain Conversion Processes

Fluidtherm Engineering
Boulder, CO 80302
004: Compact, Gas-Turbine Engine with Effective Turbine-Blade Cooling

Foster-Miller, Inc.
Waltham, MA 02154-1196
054: Synergistic Prepregging Technologies
064: Liquid Crystal Polymers for CTE Matched PWBs
078: Recovery of Oxygen from Lunar Soils in a Plasma Reactor
198: Small Liquid Pump for Space Thermal Systems

- G -

G & C Systems, Inc.
San Juan Capistrano, CA 92675
039: Applications of Artificial Intelligence to NASP

G. Miller Machine Company, Inc.
Riverhead, NY 11901-7817
170: An Active Fluorometer for Measuring Primary Productivity in the Ocean

Gait Scan, Inc.
Ridgewood, NJ 07451-1550
256: Non-Invasive Bone Strength Measurement by a Mechanical-Response Tissue Analyzer

Garman Systems, Inc.
Getzville, NY 14068-1192
069: Quick Look Modal Testing of Flexible Structures

General Digital Industries, Inc.
Huntsville, AL 35806
060: GMA Welding in Space

General Sciences Corporation
Laurel, MD 20707
187: Colored-Noise Simulation and Characterization, and Effects on Attitude Accuracy

Gumbs Associates, Inc.
East Brunswick, NJ 08816
066: Conductive Paints Based on Soluble Conducting Polymers

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HITC Superconco, Inc.
Tullytown, PA 19007
076: High-J_c, High Strength HTS Wire Using Newly Discovered Processess and Materials

Heuristicrats
Berkeley, CA 94709-1631
109: Decision-Theoretic Control of Artificial Intelligence Scheduling Systems

Hittite Microwave Corporation
Woburn, MA 01801
194: MMIC Circulator for Spacecraft Data-Transfer Applications

Honeybee Robotics
New York, NY 10012
083: A Gravity Compensation System for Simulation of On-Orbit Telerobotic Operations

Hughes Associates, Inc.
Wheaton, MD 20902
260: Perfluorocarbons as Fire Suppression Agents

Huntsville Sciences Corporation
Huntsville, AL 35805
041: Solution-Adaptive Code for Analysis of Fatigue-Crack Propagation in Aerospace Structures
205: SINDA/TRASYS Thermal-Model Development Tool Using Interactive Color Graphics

Hydrogen Consultants, Inc.
Littleton, CO 80125
254: Solid-State, Oxygen-Storage Intermetallic And Alloy Development

Hypersonics, Inc.
Palo Alto, CA 94306-4607
015: Innovative Model for Reacting Flows

Hypertech Systems
Melbourne, FL 32934-9676
139: Multi-Media Planetary HyperBook

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IAP Research, Inc.
Dayton, OH 45429-3723
014: Hypervelocity for Aerothermodynamic Experiments

Information Systems Technology, Inc.
Clarendon Hills, IL 60514
062: Feature Enhanced Ultrasonic Flaw Detection and Micro-Structure Characterization Algorithms for NDE Systems

Innovative Dynamics
Ithaca, NY 14850-1296
027: Shape Memory Alloys for Use in Rotorcraft De-Icing Systems

Innovative Research & Technology
Santa Monica, CA 90403
167: Quasi-Optical, Solid-State Multiplier Sources to 3000 GHz

Inrad, Inc.
Northvale, NJ 07647
150: Growth of Zinc Germanium Phosphide for OPO Applications

Integrated Parallel Technology
Pleasanton, CA 94588
116: Time-Warp Concurrency Control for Database Systems

Integrated Software, Inc.
Palm Bay, FL 32906-0295
112: Real-Time Expert Systems

Intelligent Automation, Inc.
Rockville, MD 20850
068: Six-Degree-of-Freedom, Active Vibration Damping for Space Applications

International Software Systems, Inc.
Austin, TX 78759
106: Creation of a NASA Specification to Executable Programs (NASA/STEP) Capability

International Solar Electric Technology
Inglewood, CA 90301
208: Lightweight, Flexible, Thin-Film Solar Cells for Space Applications

Interscience, Inc.
Troy, NY 12180
024: High-Resolution, Optical, Multichannel Transducer Array for Wind Tunnel Applications

Intersonics, Inc.
Northbrook, IL 60062
147: Laser Polarization Profiling

Irvine Sensors Corporation
Costa Mesa, CA 92626
118: Space Flight Supercomputer
136: Spacecraft On-Board Information Extraction Computer

Ithaco, Inc.
Ithaca, NY 14851-6437
186: A Digital Processor for an Earth-Horizon-Sensor Attitude Control System

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J. M. Jenco & Associates, Inc.
Covington, LA 70434-1855
259: Conceptual Design of a Purpose-Built, 1-ATA Shallow Water Diving Suit

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KMS Fusion, Inc.
Ann Arbor, MI 48106-1567
085: Real-Time Object and Robot End-Effector Tracking System
101: Virtual Reality User-Interface for Actualizing A Robot System

Ken Wanderman & Associates, Inc.
Staten Island, NY 10310
128: A Scientific Array Data Management System

Klein Associates, Inc.
Yellow Springs, OH 45387-0264
038: Applying Recognition-Primed Decision-Making to Man-Machine Interface Design

Konigsberg Instruments, Inc.
Pasadena, CA 91107-3294
258: A True General-Purpose, Biomedical Telemetry System

Ktaadn, Inc.
Newton, MA 02159
235: Intelligent Processor for Space Station Life Support System

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Laser Photonics Analytics Division
Bedford, MA 01730
162: Buried Hetrostructure PbEuSeTe/PbSnTe Long Wavelength Tunable Diode Lasers

Laser Power Research
San Diego, CA 92130
275: Fast, Reliable, Electro-Optic Modulation Technology

Lightwave Electronics Corporation
Mountain View, CA 94043

141: High-Power, High-Repetition Rate, Diode-Pumped, Solid-State Laser Transmitter
266: External Phase or Amplitude Modulator for Lasers

Liquisheet Technologies
Oakland, CA 94602
225: Impingement-Sheet Mixing for Injection of Liquid Propellants in Rocket Engines

Litecom, Inc.
Canoga Park, CA 91306-2313
229: Fiber-Optic Cable Feedthrough and Sealing

Loredan Biomedical, Inc.
Davis, CA 95617
232: Hand Physiological Evaluation And Countermeasure Device

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MATSI, Inc.
Lawrenceville, GA 30245
216: Recharcheable Zinc-Air Cell

MODAR, Inc.
Natick, MA 01760
244: Supercritical Water Reactor for Space Applications

MRJ, Inc.
Oakton, VA 22124
123: Optimization of Large Structures in a Massively Parallel Environment

Mainstream Engineering Corporation
Rockledge, FL 32955
201: Nontoxic Heat Transport Fluids for Habitat Two-Phase Thermal Control Systems

Marlow Industries, Inc.
Dallas, TX 75238-1645
195: Using Pressed and Sintered Bi-Sb to Improve Thermoelectric Coolers Below 200K

Marquest Group Incorporated
Bourne, MA 02532
183: NASA Three-Dimensional, Underwater Positioning System

Materials & Electrochemical Research
Tucson, AZ 85706
045: The Development of Febe5 Fibers Using a Dual Plasma Deposition System
049: Protective Refractory Alloy Composite Coating Using Novel LTAVD Technique

Materials Sciences Corporation
Blue Bell, PA 19422-1959
223: Failure Criteria for Carbon-Carbon Contour-Woven Integral-Throat-Exit-Cone Materials

Materials Technologies Corporation
Monroe, CT 06468
050: Environment-Resistant Coatings for Ti-Alloys

McGown, Mullican & Dunn
Nashville, TN 37201
250: Alternative Illumination Technologies for the Human Habitation of Space

Mendez R&D Associates
El Segundo, CA 90245
270: Optical Multiple Access Techniques for On Board Routing

Merritt Systems, Inc.
Merritt Island, FL 32953
086: Sensor-Based Whole-Arm Obstacle Avoidance for Redundant Robot Arm Manipulators

Microtronics Associates, Inc.
Pittsburgh, PA 15213-3728
125: A Spectro-Imager
163: Homojunction Barrier Infrared Detectors

Mid-South Engineering, Inc.
Nashville, TN 37212
061: Neural Networks for Welding Control

Modeling and Computing Services
Sunnyvale, CA 94089
124: Software for Multidisciplinary System Optimization

Multilayer Optics & X-Ray Technology Inc
Provo, UT 84602
174: A Method of Producing Ultrasmooth Presision Visible and X-Ray Mirror Blanks with Ultrastructured Materials

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Nektonics, Inc.
Cambridge, MA 02139
276: Computational Environment for Microgravity Materials Processing Simulations

Netrologic, Inc.
San Diego, CA 92122
080: Human-Machine Interaction in Human-Assisted Robotic Systems

Nielsen Engineering & Research, Inc.
Mountain View, CA 94043-2287
013: Nonlinear Control of Shear Flows

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OCA Applied Optics, Inc.
Garden Grove, CA 92641
173: Efficient Production of All-Metal Cryogenic Telescopes
177: Aspheric Surface Figuring Using Plasma-Assisted Chemical Etching

Odyssey Research Associates, Inc.
Ithaca, NY 14850-1313
107: An Intermediate Language for Formal Verification Tools

Olis Engineering
Sedalia, CO 80135
099: Centerline Imaging Module for Grasping End Effectors

Omitron, Inc.
Greenbelt, MD 20770
117: Spacecraft Supercomputer

Ophir Corporation
Lakewood, CO 80227
171: A Multi-Band, Sea-Surface-Temperature, Infrared Radiometer

Optical Air Data Systems - L.P.
Van Nuys, CA 91409
031: A Compact Optical Air-Data System for Flight Test Applications

Opticomp Corporation
Zephyr Cove, NV 89448
122: General Purpose, Optical, Vector-Matrix Multiplier

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PDA Engineering
Costa Mesa, CA 92626
043: Thermo-Chemical Structural Analysis of Carbon-Phenolics with Pore Pressure And Pyrolysis Effects
224: Rotated Ply Stacking for Carbon-Carbon Cloth Based Nozzle Components

Pacific Coast Engineering
Thousand Oaks, CA 91358
274: Feedback, Pseudomorphic HEMT, Low-Noise Amplifiers for Low-Cost Receivers

Pacific Monolithics, Inc.
Sunnyvale, CA 94086
269: GaAs MMIC Sampling Mixer for Frequency Conversion

Payload Systems, Inc.
Cambridge, MA 02142-1112
279: Comprehensive Accelerometer Data Analysis Software

Penn Laboratories, Inc.
Cartersville, GA 30120
048: Innovative Fiber Laser Furnace

Photon Physics, Inc.
Detroit, MI 48226
273: Growth of Nd:YVO4 Crystals for Laser Technology

Photonics Imaging
Northwood, OH 43619
192: Surface-Discharge, AC-Plasma, Color, Flat-Panel Display for Space Station Applications

Physical Optics Corporation
Torrance, CA 90501
135: Three-Dimensional, Stacked, Optical Memory Based On Polarization Holography
148: Large-Aperture, Holographic Optical Elements for Scanning Telescopes

Physical Sciences, Inc.
Andover, MA 01810
010: Laser-Driven Hypersonic Airbreathing Propulsion Simulator
018: Effects of Supercooling and Melt Phenomena on Particulate Radiation in Plumes
140: An Iodine Standard Lamp
213: Electrocatalysts for High-Efficiency, Solid-Polymer-Electrolyte Fuel Cell

Phytoresource Research, Inc.
College Station, TX 77840
247: Compact Lighting Technology for CELSS Flight Experiment Hardware

Polatomic, Inc.
Richardson, TX 75080
168: Universal Helium Magnetometer for Space

Polytronix, Inc.
Richardson, TX 75081
175: Optical Coatings for Infrared Detectors Using Pulsed RF Plasma Polymerizations

Potomac Photonics, Inc.
Lanham, MD 20706
264: An Ultrasensitive Microprobe Detector for Surface Contamination

Precision Combustion, Inc.
New Haven, CT 06511
006: Novel Catalytic Approach to Combustion

Princeton Scientific Instruments, Inc.
Monmouth Junction, NJ 08852
154: XUV Image Detector Array

Program Development Corp. of Scarsdale
White Plains, NY 10601
102: Interactive and Adaptive Grid Quality Assessment

Pulse Technology, Inc.
Kennesaw, GA 30144
142: A Millimeter Wave Doppler Radar for Detection of Precipitation

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Quantex Corporation
Rockville, MD 20850
023: A Novel, Polarization-Preserving, Fiberoptic Sensor for High Temperature Environments

Quest Integrated, Inc.
Kent, WA 98032
003: A New, Unsteady Mixing Model To Predict NOx Production During Rapid Mixing In a Dual Stage Combustor
012: A New, Subgrid Model for Large-Eddy Simulations of Mixing and Chemical Reaction In Turbulent Flows

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R*Scan Corporation
Minneapolis, MN 55415-1258
262: Feasibility of Numerical Thunderstorm Forecasts for Specific KSC Work Complexes

R. J. Williams & Associates
Shoreview, MN 55126
081: Analysis of the Human Musculoskeletal System for Teleoperator System Design

RPK Corporation
Athens, GA 30603
137: NASTRAN on Massively Parallel Computers

Refractory Composites, Inc.
Whittier, CA 90606
226: Mixed, Hafnium-Tantalum-Carbide, Composite Rocket Thruster Development

Remtech, Inc.
Huntsville, AL 35805
017: Rarefied Gas Effects on Aerobraking/Reentry Vehicles with Wakes

Research International, Inc.
Bothell, WA 98021
220: Solid-State Micromachined Pump for Space-Power-System Thermal Management

Robotics Research Corporation
Amelia, OH 45102-0206
087: Robot Fault-Tolerant Feedback System

Rocky Research
Boulder City, NV 89005
200: High-Temperature, Waste-Heat-Driven Cooling Using Complex-Compound Sorption Media

- S -

S. D. Miller & Associates
Harbor City, CA 90710
067: Use of Honeycomb Technology to Save Weight in Composite Flexible Blanket Insulation

SCS Telecom, Inc.
Port Washington, NY 11050
132: Novel Optical Interconnect Topologies for Digital Multiprocessors

SRS Technologies
Huntsville, AL 35806
133: Advanced Multisensor, Data-Resources Management System
204: Transient Model of Cryogenic-Bearing, Thermo-Mechanical Operating Characteristics

SSG, Inc.
Waltham, MA 02154
152: Silicon Carbide Lightweight, 1-Meter-Class Mirror Development

Sandia Systems, Inc.
Albuquerque, NM 87111
176: Automated, Deterministic Asphere Fabrication

Sarcos Research Corporation
Salt Lake City, UT 84111
095: Extended Tactile Sensing for Dextrous Robotic Hands

Satcon Technology Corporation
Cambridge, MA 02139-4507
082: An Integrated Micro-Gyroscope
094: Magnetic Bearings to Eliminate Stiction and Reduce Vibrations in Reaction/Momentum Wheels
207: Flywheel Energy Storage for Electromechanical Actuation Systems

Schellenberg Associates
Huntington Beach, CA 92647
272: Ka-Band, High Efficiency Power MMIC

Schwartz Electro-Optics, Inc.
Concord, MA 01742
267: Development of a Diode-Pumped Laser for Space-Based Communications

Search Technology, Inc.
Norcross, GA 30092
037: Knowledge-Based Tools for the Conceptual Design of Human-Machine Systems

Seca, Inc.
Huntsville, AL 35805
019: Radiation from Advanced Solid Rocket Motor Plumes

Sets Technology, Inc.
Mililani, HI 96789
153: Cold Coronagraph for Planetary Observations
165: Variable-Spatial-Resolution Infrared Spectrometer

Solidlite Corporation
Redmond, WA 98052-3562
151: High-Efficiency Frequency Doubler

Space Hardware Optimization Technology
Floyd Knobs, IN 47119
257: Advanced Avian Research Module for Microgravity Experiments

Space Tech Corporation
Ft. Collins, CO 80525
052: A New Machine Architecture for Structural Analysis
065: Automated NDE Scanner for Cracks

Spec, Inc.
Bellvue, CO 80512
145: An Airborne Particle-Imaging Nephelometer for Measuring Optical Phase Function

Speech Systems, Inc.
Tarzana, CA 91356
110: Language Engineering in Speech Recognition

Spire Corporation
Bedford, MA 01730
009: Remote, Wireless Monitoring of Positron Escape for Gauging Temperature and Strain

055: Protective Coating for Carbon-Carbon Composites
159: Radiation Hardening of Charge-Coupled Devices
166: Pyro-Electric Detectors Fabrication by Epitaxial CVD Growth on Silicon
212: 1.3 Micron for Laser Beams In(Alga)As Photovoltaic Laser Energy Converters
268: Pseudomorphic HEMTS for Millimeter Wave Communications

Statistical Sciences, Inc.
Seattle, WA 98145-1625
129: An Integrated GIS and Statistical Data Analysis System

Stirling Technology Company
Richland, WA 99352
164: A High-Efficiency, Low-Vibration, Long-Life, Pulse-Tube Spacecraft Cryocooler Employing Flexural Bearings

Stottler Henke Associates
Melbourne Beach, FL 32951
119: Artificial Intelligence Techniques for Scheduling Shuttle Processing

Stress Photonics, Inc.
Madison, WI 53705
063: Thermographic Stress Analysis and NDE via Focal Plane Array Detectors

Structural Integrity Associates
San Jose, CA 95118
042: Real-Time Monitoring of Material Degradation of Fiber Composites

Superconductor Technologies, Inc.
Santa Barbara, CA 93111-2310
074: Buffer Layers on Low Loss Substrates for High Temperature Superconducting Thin Films

Superconix, Inc.
St Paul, MN 55101
072: Epitaxial Growth of Semiconductors on High-Tc Superconductor Crystals

Superior Vacuum Technology
Eden Prairie, MN 55344
155: Strained Type II Superlattice Infrared Detectors

Swales & Associates, Inc.
Beltsville, MD 20705
105: A General Purpose Nonlinear Dynamics Analysis Package

Symbiotics, Inc.
Cambridge, MA 02139
090: MetaAgents: A Framework for Intelligent Distributed Systems
120: Integrating and Coordinating Intelligent Planning and Scheduling Tools

Synetics Corporation
Wakefield, MA 01880
091: Diagnostic Control by Means of Model Based Reasoning

Systems Control Technology, Inc.
Palo Alto, CA 94303
029: Ideal Flying Qualities for Aero-Space Craft

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TDA Research, Inc.
Wheat Ridge, CO 80033
253: Integrated Carbon-Dioxide, Humidity, and Thermal Control for an EMU Gas Stream

TPL, Inc.
Albuquerque, NM 87112
238: Organic Contaminant Monitor
241: Aerogel Processing of Ceramic Composite Membranes

Tacan Corporation
Carlsbad, CA 92008
111: Fuzzy Cognitive Maps for Mission Planning and Flight Control
188: Compact Lidar for Simultaneous Range and Velocity Measurements
228: Improved Fiber Optic Temperature Sensors for Propulsion Systems

Talandic Research Corporation
Azusa, CA 91702
157: Detector Arrays from the Direct Deposition of Superconducting Films on Diamonds

Technical Research Associates, Inc.
Salt Lake City, UT 84108-1209
047: Coated Graphites Fibers for Highly Conductive Composites

Technology Integration & Dev. Group
Billerica, MA 01821
005: Enhanced Diagnostic Methods for Planetary Gear Systems

Tetra Corporation
Albuquerque, NM 87109
075: Field Emission Enhancement and Confinement from Superconductive Surfaces

Textile Technologies, Inc.
Hatboro, PA 19040
070: Multi-Inlet Tubular Joint Structures for Spacecraft Application

Thermacore, Inc.
Lancaster, PA 17601
278: Variable Temperature Gradient Heat Pipe Furnace Element

Tleimat & Associates
Alamo, CA 94507
240: Wiped-Film Rotating-Disk Evaporator for the Reclamation of Water at Zero Gravity

Tomorrowtools
Huntsville, AL 35806
255: Body-Mounted, Head-Up, Video Display Terminal

Transitions Research Corporation
Danbury, CT 06810
190: Log-Polar Binocular Vision System
191: Log-Hough Transform Featue Detector

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Ultramet
Pacoima, CA 91331
035: Carbon-Carbon/Refractory Metal Heat Pipes for Leading-Edge Cooling on Reusable Hypersonic Vehicles
057: Advanced Powder Synthesis for Improved High Temperature Light Alloys
227: Unconventional Long-Life Chemical Rocket Thrust Chambers

United Applied Technologies, Inc.
Huntsville, AL 35807
056: Remotely Deployable Self-Rigidizing Composite Space Structures

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Vigyan Research Associates, Inc.
Hampton, VA 23666-1325
028: Pilot Wx Advisor

Visual Computing, Inc.
Mountain View, CA 94043
114: Interactive, Three-Dimensional Flow Solver Software Project

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Windrock Associates
Oak Ridge, TN 37830
263: Pressure-Time Flow Measurement

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Xsirius, Inc.
Marina Del Ray, CA 90292
182: New Concepts for HGI_2-Scintillator, Gamma-Ray Spectroscopy

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Zonic Corporation
Milford, OH 45150
184: Adaptation of a Multichannel Structural Analyzer as an Integrated Controls-Structures Design and Analysis Tool

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Ames Research Center

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Goddard Space Flight Center

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Johnson Space Center

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Kennedy Space Center

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184	90-1-09.01-1911
185	90-1-09.01-9995
212	90-1-10.04-6000

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001	90-1-01.01-1515
002	90-1-01.01-6576
003	90-1-01.01-9500
004	90-1-01.02-0875
005	90-1-01.02-3779
006	90-1-01.02-5215
007	90-1-01.02-6576
008	90-1-01.03-1228
009	90-1-01.03-6000
010	90-1-01.04-0003
026	90-1-02.11-8610
027	90-1-03.01-0533
042	90-1-04.01-8200
043	90-1-04.01-8900
044	90-1-04.02-4888
045	90-1-04.03-1980A
046	90-1-04.03-4888A
047	90-1-04.03-8080
048	90-1-04.03-8476
051	90-1-04.05-2380
052	90-1-04.05-8166
072	90-1-04.15-0046
073	90-1-04.15-6700
074	90-1-04.15-7646A
075	90-1-04.15-8623
207	90-1-10.01-0540
208	90-1-10.01-4427
209	90-1-10.01-8888
213	90-1-10.05-0003A
219	90-1-10.08-3800
220	90-1-10.08-7831
225	90-1-11.04-6052
226	90-1-11.04-8061
227	90-1-11.05-0236
228	90-1-11.08-1010
229	90-1-11.08-5061
270	90-1-14.05-0497
271	90-1-14.05-0703
272	90-1-14.05-3907
274	90-1-14.07-4605
276	90-1-15.01-0101
280	90-1-15.01-8086
280	90-1-15.02-3800

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016	90-1-02.04-3304
017	90-1-02.04-8581
018	90-1-02.05-0003
019	90-1-02.05-2008
041	90-1-04.01-8122
049	90-1-04.04-1980
050	90-1-04.04-5200
059	90-1-04.08-1933
060	90-1-04.08-2200
061	90-1-04.08-8877A
098	90-1-05.09-0402
099	90-1-05.09-0718
100	90-1-05.09-2567
101	90-1-05.09-8500A
133	90-1-07.07-7000
152	90-1-08.07-0204
165	90-1-08.12-5262
176	90-1-08.20-1040A
177	90-1-08.20-1667
178	90-1-08.20-6881A
183	90-1-08.25-1311
203	90-1-09.12-5911
204	90-1-09.12-7000
205	90-1-09.12-8122
206	90-1-09.13-3800
221	90-1-10.08-9399
222	90-1-11.01-1515
223	90-1-11.03-8400
224	90-1-11.03-8900B
235	90-1-12.02-0054
238	90-1-12.02-3648
241	90-1-12.03-3648
243	90-1-12.03-4100A
249	90-1-12.05-2075
250	90-1-12.05-3118
255	90-1-12.09-1060
259	90-1-12.12-8285
263	90-1-13.05-0572
277	90-1-15.01-0760
278	90-1-15.01-6551

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129	90-1-07.04-8707
130	90-1-07.04-9000
131	90-1-07.05-1813
143	90-1-08.02-1419
144	90-1-08.02-6078
230	90-1-11.09-5649
231	90-1-11.09-6522

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NAS01-19251	146	90-1-08.03-6239
NAS01-19252	108	90-1-06.03-3474
NAS01-19253	107	90-1-06.03-2020
NAS01-19254	054	90-1-04.06-3200
NAS01-19255	124	90-1-06.11-1123
NAS01-19256	013	90-1-02.02-9457B
NAS01-19257	055	90-1-04.06-6000
NAS01-19258	212	90-1-10.04-6000
NAS01-19259	077	90-1-04.15-9450
NAS01-19260	058	90-1-04.07-1933
NAS01-19261	029	90-1-03.03-2233
NAS01-19262	063	90-1-04.09-8120
NAS01-19263	056	90-1-04.06-9709
NAS01-19264	053	90-1-04.06-1477
NAS01-19265	126	90-1-07.01-9271A
NAS01-19266	150	90-1-08.06-1910
NAS01-19267	037	90-1-03.09-1457
NAS01-19268	125	90-1-07.01-0888
NAS01-19269	024	90-1-02.09-7500
NAS01-19270	014	90-1-02.03-1806
NAS01-19271	025	90-1-02.10-4400
NAS01-19272	184	90-1-09.01-1911
NAS01-19273	103	90-1-06.01-3304
NAS01-19274	062	90-1-04.09-1911A
NAS01-19275	123	90-1-06.11-0700
NAS01-19276	132	90-1-07.06-0760
NAS01-19277	080	90-1-05.01-0970
NAS01-19278	102	90-1-06.01-1732
NAS01-19279	149	90-1-08.06-0867
NAS01-19280	023	90-1-02.09-2701
NAS01-19281	185	90-1-09.01-9995
NAS01-19282	082	90-1-05.03-0540A
NAS01-19283	151	90-1-08.06-7528
NAS01-19284	145	90-1-08.03-0490
NAS01-19285	035	90-1-03.07-0236
NAS01-19286	057	90-1-04.07-0236
NAS01-19289	022	90-1-02.06-8228A

NAS2: Ames Research Center

NAS02-13300	034	90-1-03.06-0321
NAS02-13301	031	90-1-03.05-3636
NAS02-13302	021	90-1-02.06-8228
NAS02-13303	040	90-1-03.11-1679
NAS02-13304	039	90-1-03.10-7212A
NAS02-13305	033	90-1-03.05-8100
NAS02-13306	032	90-1-03.05-6100
NAS02-13340	109	90-1-06.04-5810
NAS02-13344	122	90-1-06.10-4176
NAS02-13345	245	90-1-12.04-4100A
NAS02-13346	240	90-1-12.03-0369
NAS02-13348	253	90-1-12.07-7830
NAS02-13349	256	90-1-12.10-4164G
NAS02-13350	257	90-1-12.10-9591
NAS02-13351	114	90-1-06.06-5682
NAS02-13353	115	90-1-06.06-7450
NAS02-13354	012	90-1-02.01-9500
NAS02-13355	169	90-1-08.16-6239
NAS02-13356	251	90-1-12.05-9300
NAS02-13357	020	90-1-02.06-3304
NAS02-13358	030	90-1-03.04-7300
NAS02-13359	038	90-1-03.09-2691
NAS02-13360	036	90-1-03.08-9983
NAS02-13362	164	90-1-08.11-4000A
NAS02-13365	011	90-1-02.01-2027
NAS02-13367	015	90-1-02.03-3013
NAS02-13368	067	90-1-04.12-5367

NAS3: Lewis Research Center

NAS03-16145	008	90-1-01.03-1228
NAS03-25922	072	90-1-04.15-0046
NAS03-25923	271	90-1-14.05-0703
NAS03-25924	274	90-1-14.07-4605
NAS03-25925	270	90-1-14.05-0497
NAS03-25926	074	90-1-04.15-7646A
NAS03-25927	075	90-1-04.15-8623
NAS03-25938	073	90-1-04.15-6700
NAS03-25939	272	90-1-14.05-3907
NAS03-25978	280	90-1-15.02-3800
NAS03-25979	279	90-1-15.01-8086
NAS03-26132	276	90-1-15.01-0101
NAS03-26133	048	90-1-04.03-8476
NAS03-26136	209	90-1-10.01-8888
NAS03-26137	045	90-1-04.03-1980A
NAS03-26138	046	90-1-04.03-4888A
NAS03-26139	004	90-1-01.02-0875
NAS03-26140	006	90-1-01.02-5215
NAS03-26141	005	90-1-01.02-3779
NAS03-26142	007	90-1-01.02-6576
NAS03-26143	026	90-1-02.11-8610
NAS03-26144	002	90-1-01.01-6576
NAS03-26146	010	90-1-01.04-0003
NAS03-26147	009	90-1-01.03-6000
NAS03-26148	219	90-1-10.08-3800
NAS03-26149	051	90-1-04.05-2380
NAS03-26151	043	90-1-04.01-8900
NAS03-26152	052	90-1-04.05-8166
NAS03-26153	042	90-1-04.01-8200
NAS03-26154	027	90-1-03.01-0533
NAS03-26155	047	90-1-04.03-8080
NAS03-26232	207	90-1-10.01-0540
NAS03-26233	208	90-1-10.01-4427
NAS03-26234	001	90-1-01.01-1515
NAS03-26235	220	90-1-10.08-7831
NAS03-26236	213	90-1-10.05-0003A

NAS03-26237	044	90-1-04.02-4888
NAS03-26238	228	90-1-11.08-1010
NAS03-26239	225	90-1-11.04-6052
NAS03-26240	229	90-1-11.08-5061
NAS03-26241	227	90-1-11.05-0236
NAS03-26242	003	90-1-01.01-9500
NAS03-26243	226	90-1-11.04-8061

NAS5: Goddard Space Flight Center

NAS05-30565	210	90-1-10.02-6700
NAS05-31381	159	90-1-08.09-6000B
NAS05-31382	106	90-1-06.02-5700
NAS05-31383	134	90-1-07.08-7978
NAS05-31384	137	90-1-07.10-1212
NAS05-31385	140	90-1-08.01-0003
NAS05-31386	142	90-1-08.01-8315
NAS05-31387	141	90-1-08.01-0755
NAS05-31388	147	90-1-08.04-1772
NAS05-31389	148	90-1-08.05-3088
NAS05-31390	065	90-1-04.11-8166
NAS05-31391	083	90-1-05.03-0661
NAS05-31392	158	90-1-08.09-5411A
NAS05-31393	266	90-1-14.02-0755
NAS05-31395	267	90-1-14.02-2299
NAS05-31396	085	90-1-05.03-8500A
NAS05-31397	094	90-1-05.07-0540A
NAS05-31398	198	90-1-09.10-3200
NAS05-31399	181	90-1-08.23-0760
NAS05-31401	186	90-1-09.03-7640
NAS05-31402	118	90-1-06.08-8211
NAS05-31402	187	90-1-09.04-2700
NAS05-31403	194	90-1-09.07-7267
NAS05-31404	064	90-1-04.11-3200
NAS05-31405	081	90-1-05.02-0649
NAS05-31406	084	90-1-05.03-2491
NAS05-31407	104	90-1-06.02-4242
NAS05-31408	105	90-1-06.02-5500
NAS05-31409	117	90-1-06.08-1700
NAS05-31410	128	90-1-07.02-7253
NAS05-31411	156	90-1-08.09-2231
NAS05-31412	162	90-1-08.10-2650
NAS05-31413	171	90-1-08.18-1512
NAS05-31414	174	90-1-08.19-3972
NAS05-31415	179	90-1-08.21-2200
NAS05-31416	180	90-1-08.22-3434
NAS05-31417	175	90-1-08.19-7045
NAS05-31418	199	90-1-09.10-8177
NAS05-31419	157	90-1-08.09-3000
NAS05-31420	197	90-1-09.10-2231
NAS05-31421	154	90-1-08.09-0774
NAS05-31422	127	90-1-07.02-6207

NAS7: Jet Propulsion Laboratory

NAS07-1114	153	90-1-08.08-5262
NAS07-1115	167	90-1-08.14-3686
NAS07-1116	093	90-1-05.06-2567
NAS07-1117	173	90-1-08.19-1667
NAS07-1118	136	90-1-07.09-8211
NAS07-1119	268	90-1-14.03-6000
NAS07-1120	168	90-1-08.15-2292
NAS07-1121	195	90-1-09.09-4900
NAS07-1122	155	90-1-08.09-1929
NAS07-1123	092	90-1-05.06-0815O
NAS07-1124	135	90-1-07.09-3088
NAS07-1125	172	90-1-08.19-0867
NAS07-1126	116	90-1-06.07-8854
NAS07-1127	273	90-1-14.06-8585
NAS07-1128	269	90-1-14.04-8000
NAS07-1129	139	90-1-07.11-2732
NAS07-1130	182	90-1-08.24-6655
NAS07-1131	214	90-1-10.06-1140
NAS07-1132	076	90-1-04.15-9023A
NAS07-1133	163	90-1-08.11-0888
NAS07-1134	068	90-1-04.13-2407
NAS07-1135	160	90-1-08.09-6621
NAS07-1136	196	90-1-09.09-6352
NAS07-1137	211	90-1-10.03-2113
NAS07-1138	161	90-1-08.09-9806
NAS07-1139	138	90-1-07.11-2567
NAS07-1140	170	90-1-08.18-1500
NAS07-1141	275	90-1-14.08-0700
NAS07-1142	215	90-1-10.06-9450A
NAS07-1143	166	90-1-08.13-6000

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NAS08-33895	263	90-1-13.05-0572
NAS08-33897	183	90-1-08.25-1311
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NAS08-38885	018	90-1-02.05-0003
NAS08-38886	101	90-1-05.09-8500A
NAS08-38887	017	90-1-02.04-8581
NAS08-38888	205	90-1-09.12-8122
NAS08-38889	049	90-1-04.04-1980
NAS08-38890	059	90-1-04.08-1933
NAS08-38891	238	90-1-12.02-3648
NAS08-38892	016	90-1-02.04-3304
NAS08-38893	152	90-1-08.07-0204
NAS08-38894	177	90-1-08.20-1667
NAS08-38896	250	90-1-12.05-3118
NAS08-38898	204	90-1-09.12-7000
NAS08-38899	221	90-1-10.08-9399
NAS08-38900	223	90-1-11.03-8400
NAS08-38901	278	90-1-15.01-6551
NAS08-38902	243	90-1-12.03-4100A
NAS08-38903	133	90-1-07.07-7000
NAS08-38904	222	90-1-11.01-1515
NAS08-38905	165	90-1-08.12-5262
NAS08-38906	099	90-1-05.09-0718

NAS08-38907	041	90-1-04.01-8122
NAS08-38908	060	90-1-04.08-2200
NAS08-38909	241	90-1-12.03-3648
NAS08-38910	249	90-1-12.05-2075
NAS08-38911	178	90-1-08.20-6881A
NAS08-38912	224	90-1-11.03-8900B
NAS08-38913	277	90-1-15.01-0760
NAS08-38914	098	90-1-05.09-0402
NAS08-38915	203	90-1-09.12-5911
NAS08-38916	100	90-1-05.09-2567
NAS08-38917	050	90-1-04.04-5200
NAS08-38918	061	90-1-04.08-8877A
NAS08-38919	176	90-1-08.20-1040A
NAS08-38920	235	90-1-12.02-0054
NAS08-38921	206	90-1-09.13-3800
NAS08-38922	019	90-1-02.05-2008
NAS08-38923	255	90-1-12.09-1060

NAS9: Johnson Space Center

NAS09-18449	248	90-1-12.05-0700
NAS09-18450	079	90-1-04.16-3260
NAS09-18451	218	90-1-10.07-9892
NAS09-18452	096	90-1-05.08-2075
NAS09-18453	078	90-1-04.16-3200
NAS09-18454	069	90-1-04.14-2733
NAS09-18455	192	90-1-09.06-1024
NAS09-18456	200	90-1-09.11-0851A
NAS09-18457	095	90-1-05.08-0559A
NAS09-18458	091	90-1-05.05-9090
NAS09-18459	111	90-1-06.05-1010
NAS09-18460	188	90-1-09.05-1010
NAS09-18461	190	90-1-09.05-8988A
NAS09-18462	088	90-1-05.05-2806
NAS09-18463	193	90-1-09.06-9388
NAS09-18464	236	90-1-12.02-0769
NAS09-18465	237	90-1-12.02-1545
NAS09-18466	234	90-1-12.01-9769
NAS09-18467	189	90-1-09.05-5649
NAS09-18468	239	90-1-12.02-6800
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NAS09-18471	201	90-1-09.11-3550
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NAS09-18475	110	90-1-06.05-0885
NAS09-18476	097	90-1-05.08-7730
NAS09-18477	242	90-1-12.03-4100
NAS09-18478	113	90-1-06.05-3550
NAS09-18479	089	90-1-05.05-3474
NAS09-18480	202	90-1-09.11-3800A
NAS09-18481	071	90-1-04.14-7351
NAS09-18482	252	90-1-12.06-7947A
NAS09-18483	217	90-1-10.07-1460
NAS09-18484	233	90-1-12.01-5090
NAS09-18485	112	90-1-06.05-1986
NAS09-18486	264	90-1-13.06-3031
NAS09-18487	090	90-1-05.05-3635
NAS09-18488	070	90-1-04.14-5325A
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NAS10: Kennedy Space Center

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NAS10-11756	260	90-1-13.01-0505
NAS10-11757	247	90-1-12.04-8606A
NAS10-11758	246	90-1-12.04-7653A
NAS10-11759	263	90-1-13.03-1424
NAS10-11760	121	90-1-06.09-4122
NAS10-11761	258	90-1-12.11-0016
NAS10-11762	261	90-1-13.03-0070A
NAS10-11763	120	90-1-06.09-3633
NAS10-11764	119	90-1-06.09-1692B

NAS13: Stennis Space Center

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NAS13-435	143	90-1-08.02-1419
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