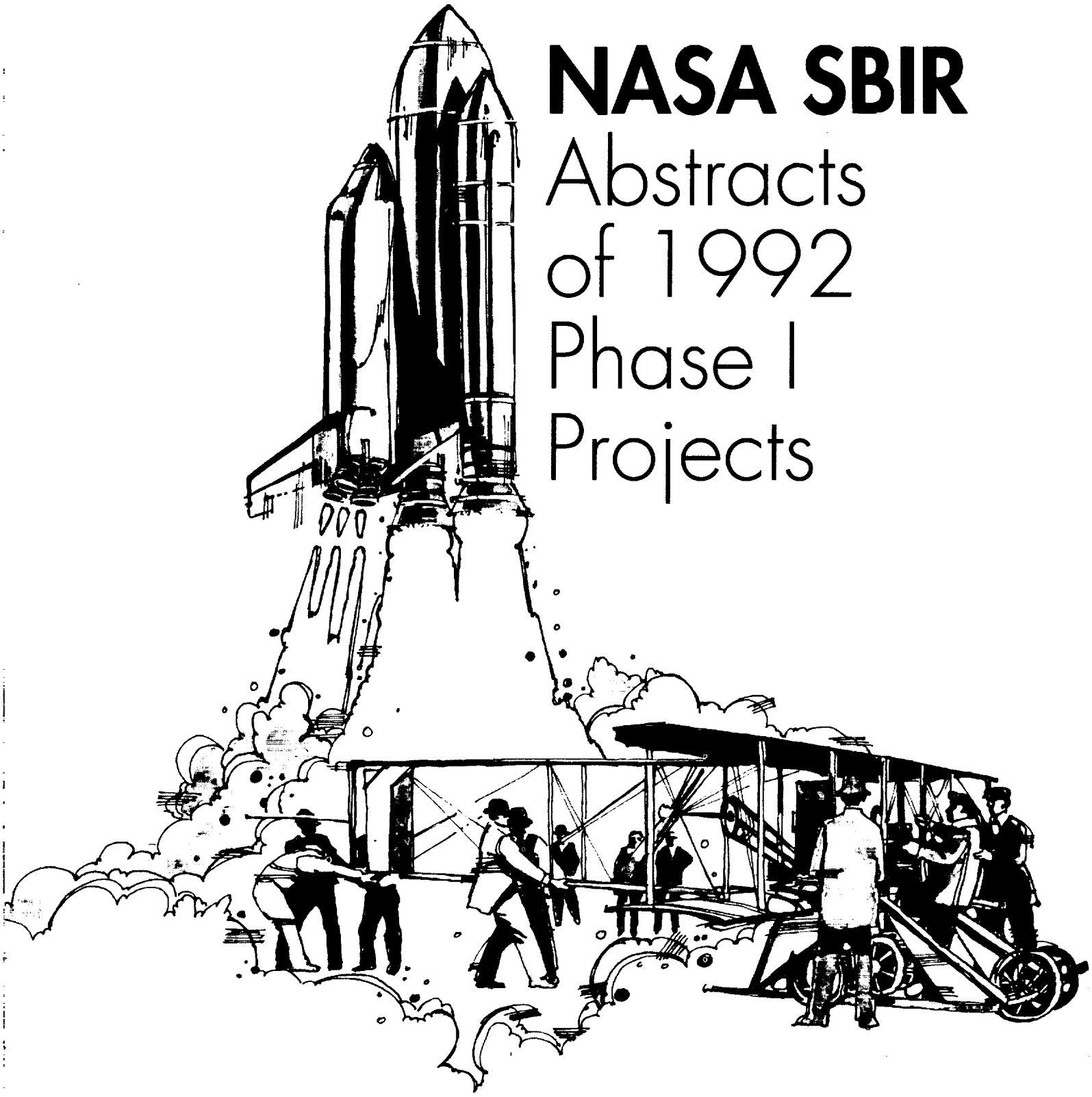
SBIR - 92 - 2

NASA SBIR

Abstracts of 1992 Phase I Projects



Small Business Innovation Research Program
Washington, DC 20546

Introduction

Objective

This document, *Abstracts of 1992 Phase I Projects*, describes the objectives of 346 projects placed under contract by the Small Business Innovation Research (SBIR) program of the National Aeronautics and Space Administration (NASA). These projects were selected competitively from among proposals submitted to NASA in response to the *1992 SBIR Program Solicitation.*

Contents

The basic document consists of edited, non-proprietary abstracts of the winning proposals submitted by small businesses. The abstracts are presented under the 15 technical topics within which Phase I proposals were solicited. Each project has been assigned a sequential identifying number from 001 to 346, 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 1992 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 1992 Phase I Projects

The closing date for the 1992 SBIR Phase I Program Solicitation was July 21, 1992, at which time 2535 proposals had been received. Following evaluation and selection of proposals for contract negotiation, 6-month fixed-price contracts were placed for 346 projects with 254 small businesses in 34 states to determine the feasibility of the proposed innovations. All projects were conducted during calendar year 1993. It is planned that approximately half of the successfully completed Phase I projects will be chosen in late 1993 and early 1994 for continuation into Phase II.

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 1992 included the 194 subtopics listed in Appendix B.

Program Management

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

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

Project Information

Each project description begins with the serial number and the project number. The project number is composed of the program year (92), 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.

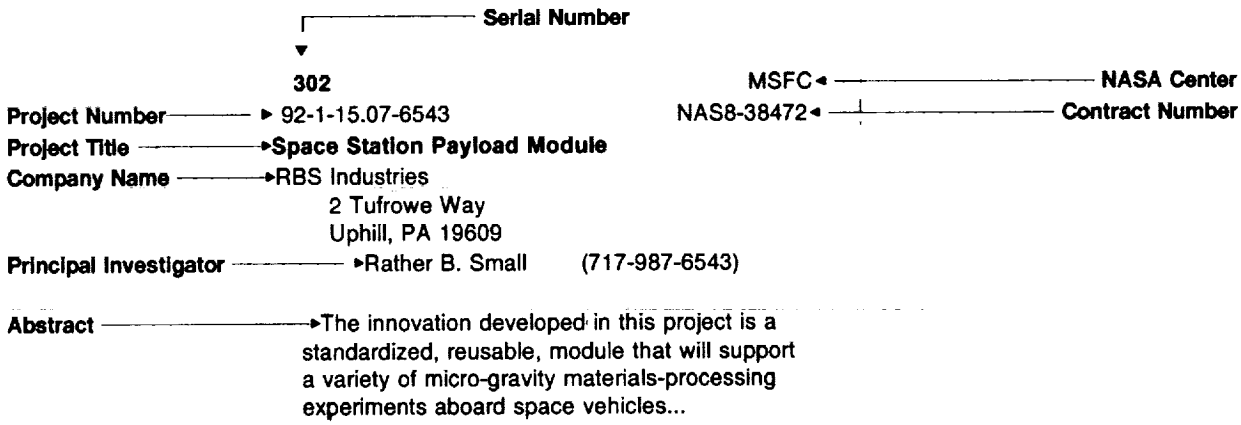
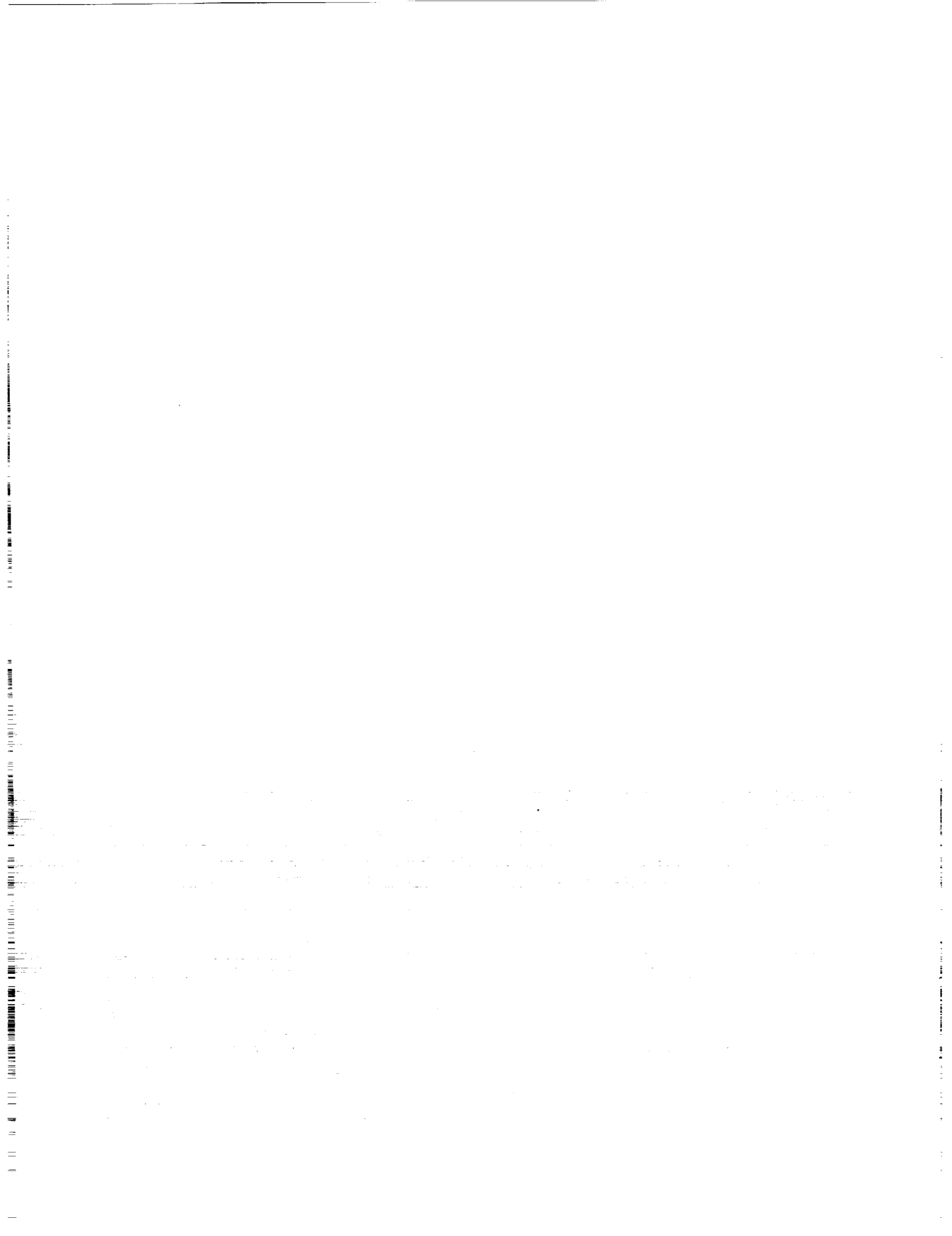


Table of Contents

Abstracts of NASA SBIR 1992 Phase I Projects



Small Business Innovation Research

Abstracts of 1992 Phase I Projects

01: Aeronautical Propulsion and Power

001 LeRC
92-1-01.01-2600 NAS03-26912
Advanced Turbulence Models on Unstructured Triangular Meshes
Fluent, Inc.
10 Cavendish Court, Centerra Resource Park
Lebanon, NH 03766
Jayathi Y. Murthy (603-643-2600)

In recent years, there has been great interest in unstructured triangular and/or tetrahedral meshes for flow problems. These meshes offer geometric flexibility and the ability to do solution-adaptive calculations. However, most solvers based on this topology deal only with Euler flows. This project's objective is to develop advanced models for unstructured triangular and/or tetrahedral meshes addressing the basic numerical issues–the generation of viscous meshes, robust and accurate upwinding schemes, and the development of implicit solvers using multi-grid methods which do not require elaborate geometric constructions. These numerical advances will be used to compute turbulence with advanced models which account for rotation, separation, and curvature. Phase I will demonstrate the viability of the numerical schemes. The standard high-Re κ-ε model will be used. Phase II will extend the basic numerical methods developed in Phase I to more complex models–low-Re models and second-moment closure models. The computation of stretched meshes will also be addressed. The resultant code will greatly expand the ability of triangular and/or tetrahedral solvers to address practical turbulent flows.

Potential Commercial Applications: Solvers which are based on the triangular and/or tetrahedral unstructured mesh topology will find wide use in industry because they greatly reduce the time required to set up meshes. Advanced turbulence models will widen the scope of these solvers so that flows in turbomachinery, combustion, manufacturing, and materials processing can be computed more accurately.

***

002 LeRC
92-1-01.01-3800 NAS03-26904
Advanced Software for Soot Modeling
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
James J. Barry (603-643-3800)

This project addresses the need for improved analytical tools for predicting soot formation and behavior in combustion processes by developing an innovative software package. The software will model the processes of soot nucleation, surface growth, coagulation, oxidation, and radiation based on a polydisperse aerosol model. The soot model will take the form of a separate software module linkable to existing combustion and computational fluid dynamics codes.

Potential Commercial Applications: The software will be applicable for simulating combustion processes and exhaust emissions. The soot software module could be coupled to many different combustion and computational fluid dynamics codes, both public-domain and commercial.

***

003 LeRC
92-1-01.01-8145 NAS03-26913
Advanced Computational Fluid Dynamics Tools for Design of Combustors and Nozzles
Daat Research Corporation
17 Montview Drive
Lyme, NH 03768
Arkady S. Dvinsky (603-643-8145)

A computational fluid dynamics tool that offers significant improvements in computational speed for modeling high speed chemical reacting flows will be developed. Phase I will demonstrate the capabilities of the CFD techniques for modeling flows in the Reacting Shear Layer Facility at NASA Lewis Research Center. The computed results will be compared against the available data. Based on the results of numerical experiments, Phase II will develop specifications for the computer program, a plan for additional required capa-

bilities, and the delivery of the completed computer program to NASA.

Potential Commercial Applications: A predictive tool that can model propulsion systems is important to NASA and commercial aircraft and rocket engine manufacturers. With such predictive tools, development of new engines will be accomplished more quickly and economically.

***

004 LeRC
92-1-01.02-0236 NAS03-26841
Cooled Porous Ceramic Vane for High-Temperature Turbine Engine Components
Ultramet
12173 Montague Street
Pacoima, CA 91331
Sangvavann Heng (818-899-0236)

Improved turbojet engine efficiency can be achieved through increasing the level of the engine's operating temperature. Unfortunately, current construction materials are limited in temperature capability and require excessive cooling when gas temperatures exceed approximately 1260°C. To meet the integrated high-performance turbine engine technology (IHPTET) initiative's requirements of doubling thrust-to-weight ratio and decreasing specific fuel consumption by 50 percent by the end of the century, engine operating temperatures must be increased to approximately 1540-1760°C while coolant flow penalties are reduced. These penalties can be reduced, to a certain extent, through the use of advanced composite materials (C-SiC and SiC-SiC). However, these materials are still not capable of extended lifetimes at temperatures above approximately 1370-1430°C. To allow successful turbine operation in the 1650°C temperature regime, efficient cooling schemes must be developed for these advanced materials. In Phase I, a preliminary design and supporting database for the production of a cooled C-SiC stator vane will be developed. Construction will consist of a structural ceramic foam core supporting a transpiration-cooled C-SiC composite face-sheet. Critical issues of heat transfer efficiency, cooled composite fabrication, and the effect of cooling holes and channels on mechanical properties will be resolved through coupon fabrication, testing, and modeling.

Potential Commercial Applications: Cooled ceramic blades will make their first impact in cruise missile engines after successful testing in the Phase III IHPTET demonstrator engine. Cooled ceramic exhaust nozzle components are expected to replace current metallic and carbon-carbon designs due to the easy maintainability of ceramic components, with initial engine testing occurring within one to three years.

***

005 LeRC
92-1-01.02-0540A NAS03-26723
A Variable-Speed, Constant-Frequency, Integral, Induction Starter-Generator
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
James R. Downer (617-661-0540)

Turbine engines are started via an electric starter driven by a start cart. The starter spins the gas generator to the minimum speed for igniting the combustor, then accelerates the engine to idle. In flight, electric power is provided by a separate generator. This project will develop a preliminary design of an integral starter-generator (IIS-G) based on an induction machine. The IIS-G will reside within a turbine engine and replace the existing starter and integral drive generator. An IIS-G will benefit overall engine design weight and performance, and will either allow for the redesign or elimination of the auxiliary gearbox. This system will also allow the bypass air ducting to be redesigned for optimum thrust. The IIS-G will be compatible with aircraft electric power distribution systems employing pulse-density modulation, which have been developed at the NASA Lewis Research Center.

Potential Commercial Applications: The integral induction starter-generator will be immediately marketable to aircraft engine manufacturers for use in advance system developments for the integrated high-performance turbine engine technology initiative. Major manufacturers are interested in this technology because eliminating the auxiliary gearbox will reduce weight.

***

006 LeRC
92-1-01.02-5094 NAS03-26718
High-Speed Inlet Design Using Computational Fluid Dynamics
Rose Engineering & Research, Inc.
P.O. Box 5146
Incline Village, NV 89450
William C. Rose (702-831-5094)

Although much discussion has been devoted to the promise of computational fluid dynamics (CFD) as a useful design tool, little has been done to establish CFD as a credible element of a working design process for high-speed engine inlet systems. Additional work must be done to utilize CFD in day-to-day design problems of supersonic and hypersonic inlets. CFD has been used exclusively as an analysis tool without being applied to derive the aerodynamic contours used in the definition of the high-speed inlet. Recently, the firm has used CFD in a design process which is entirely manual, requiring extensive "man-in-the-loop" efforts. This project will investigate how modern mathematical optimization techniques, in conjunction with existing CFD analysis codes, can lead to the automation of the inlet design process.

Potential Commercial Applications: The new high-speed inlet design process will reduce the amount of work involved in deriving contours for novel configurations. When time and manpower requirements are reduced, substantial use of this design process code will be expected from the commercial aircraft industry.

***

007 LeRC
92-1-01.01-6576 NAS03-26717
Innovative Variable Geometry Fuel-Air Premix Tube for Low NO_x Gas Turbine Combustors
CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
D. Scott Crocker (205-536-6576)

Lean-premixed-prevaporized (LPP) combustors provide an effective method for meeting low NO_x requirements in engines with high combustor inlet temperature and pressure. These conditions are expected in the high speed civil transport and future advanced subsonic civil transport aircraft. At present, reliable variable geometry premixing devices that provide adequate fuel-air mixing, without risk of autoignition or flashback, have yet to be demonstrated. This project will explore such a variable geometry premix tube. Phase I will evaluate several innovative concepts for providing superior mixing with minimal residence time, as well as a novel variable geometry mechanism. Feasibility demonstrations of the selected designs will be accomplished using a three-dimensional turbulent flow analysis. The analysis will include a liquid droplet spray and evaporation model. The results will be reviewed and assessed with the assistance of the General Electric Corporation, the selected subcontractor. In Phase II, the most promising designs will be optimized using a combined numerical and experimental approach. Experimental tests will be performed using existing experimental rigs at General Electric or NASA Lewis Research Center. Premix tube concepts that are successfully demonstrated in Phase II will have strong potential for future transition into commercial and military low-NO_x combustors.

Potential Commercial Applications: The final product of this project will be a variable geometry premix tube capable of providing superior fuel-air mixing for low-NO_x, LPP combustors. This product will be of significant interest to gas turbine engine manufacturers.

***

008 LeRC
92-1-01.03-0900 NAS03-26716
Silicon-Carbide Ultraviolet and Near-Ultraviolet Optoelectronics
Kulite Semiconductor Products, Inc.
One Willow Tree Road
Leonia, NJ 07605
Joseph S. Shor (201-461-0900)

Semiconductor light sources and optoelectronics are currently limited in wavelength to the visible and infrared portions of the spectrum. The lowest wavelength devices currently available are blue light emitting diodes (LEDs), fabricated from 6H-SiC. However, SiC has an indirect band gap which limits the efficiency of optical devices. Recently, reports suggest that microcrystalline pores in semiconductors can cause bandgap widening and direct bandgap transitions in indirect bandgap materials. This project will develop ultraviolet (UV) and near-ultraviolet (near-UV) optoelectronics capability in SiC by fabricating quantum-sized porous structures in SiC. The goal of Phase I is to form porous SiC layers that exhibit UV luminescence. In Phase II, a UV optoelectronic device, namely a UV LED, will be developed and tested.

Potential Commercial Applications: UV-emitting porous SiC will extend the capability of optoelectronics by including lower wavelengths in semiconductor light sources and optoelectronic devices. Among its applications, a UV LED can be used in high spacial resolution optical storage and, in optical communication systems, as a light source compatible with UV fibers and receivers.

***

009 LeRC
92-1-01.03-1105 NAS03-26905
An Optical Instrument to Measure Liquid Water Content and Droplet Spectra in Clouds
Spec, Inc.
5401 Western Avenue
Boulder, CO 80301
R. Paul Lawson (303-449-1105)

Measuring liquid water content and drop spectra in clouds is fundamental to most meteorologic studies such as the formation and evolution of precipitation, the radiative effect of clouds on climate change, atmospheric chemistry, and aircraft icing. Presently, measurements of liquid water content in clouds are notoriously unreliable. While some improvements have occurred over the past two decades, instruments available for the measurement of cloud liquid water content still perform inadequately. Phase I will investigate an optical technique that provides a direct measurement of liquid water content and drop spectra from an ensemble of drops in the sample volume. A prototype instrument will be built that measures the forward scattered light with an angular resolution of 0.033°. The angular measurements of light intensity can be processed in real time to

provide two outputs: liquid water content after appropriate weighting of the basis functions and drop spectra from inversion of the (overdetermined) intensity matrix. These concurrent measurements can be made with a spatial resolution of 0.1 m from an aircraft. In Phase II, an airborne version of the instrument will be built and tested.

Potential Commercial Applications: An instrument which reliably measures liquid water content and drop spectra in clouds will be useful on research aircraft, and may be necessary to evaluate the effects of clouds on climate change. The instrument might also be used as an icing severity indicator on passenger and military aircraft. As a ground-based device, the instrument will not require airspeed measurements and can be used to measure the riming rate on mountaintops, providing an estimate of acid deposition. It can also be used to measure visibility at airports.

***

010 LeRC
92-1-01.03-9106 NAS03-26911
Enhanced Performance Seeking Control Using Neural-Network-Based State Estimation
Neurodyne, Inc.
8 Marlborough Street, Suite 4
Boston, MA 02116
Theresa W. Long (617-437-9106)

Future aircraft will require integrated flight and propulsion control systems to satisfy critical mission requirements. As a result of increased constraints to satisfy these requirements, alternative approaches to traditional methods must be examined. Aircraft flight and propulsion control systems are traditionally designed to operate independently. This often results in a system where performance is compromised for robustness and operability. Under a program sponsored by NASA-Dryden, the performance seeking control algorithm uses on-board models of the inlet, engine, and nozzle to optimize total propulsion system performance in-flight. This system has resulted in significant increases in maximum thrust while reducing fuel consumption. However, a nonlinear adaptive estimation component is needed to adapt the on-board models for off-nominal behavior such as engine deterioration and engine-to-engine variations. The firm will team with Scientific Systems and McDonnell Douglas in the development of a nonlinear adaptive engine identification method using a combination of stochastic realization algorithms and neural-network-based Kalman filtering for integrated flight and propulsion control. This effort will also utilize neural network processing hardware developed by NASA Jet Propulsion Laboratory, which is compatible with the PSC vehicle management system flight computer.

Potential Commercial Applications: Application of this system to commercial aircraft could significantly affect civil transportation as a result of the ability to optimize engine performance, increase engine life, and reduce fuel consumption.

***

011 LeRC
92-1-01.04-1122 NAS03-26929
Advanced Scramjet Combustor Technology
Science Research Laboratory, Inc.
15 Ward Street
Somerville, MA 02143
Stephen Fulghum (617-547-1122)

Combustion technology is currently limited by flame stabilization techniques, which impose operating constraints and losses detrimental to overall scramjet performance for NASA aerospace applications. A new concept, based on initiating and sustaining combustion via volumetric production of free radicals with an electron beam, may lead to efficient scramjet operation over a significantly higher range of Mach numbers (M4-M25). Proof-of-concept H_2-air experiments have demonstrated that radical production by uniform injection of an electron beam can produce rapid volumetric ignition at temperatures well below autoignition, with electron beam doses small compared to mixture specific heating values. Radical production, promoting more rapid chain branching in the combustion process, is via electron-molecule dissociation. High electron beam source efficiency and large gas penetration depths offer significant advantages over alternative approaches. Phase I objectives are to design an experiment which measures ignition delay time as a function of relevant parameters for three fuels (H_2-air, ethene-air, and ethane-air), and to extend current electron-beam-initiated combustion models to determine optimal experimental operating regimes. Ignition time delay will be measured in Phase II experiments which will establish feasibility by comparing measured time delays and corresponding electron-beam energy dose with feasibility criteria for scramjet propulsion.

Potential Commercial Applications: In addition to improving scramjet performance at high Mach numbers, electron-beam-enhanced combustor technology will have a broad range of commercial applications in industrial combustors, which also have limitations in performance imposed by existing flame stabilization techniques.

***

02: Aerodynamics and Acoustics

012 ARC
92-1-02.01-1400A NAS02-13797
Multidimensional Wave Models for Solution-Adaptive Grid Generation
Vigyan, Inc.
30 Research Drive
Hampton, VA 23666-1325
Paresh Parikh (804-865-1400)

This project will develop a solution-adaptive unstructured grid generation methodology for two-dimensional flow, using wave orientation information derived from a multidimensional wave decomposition of the flow data. The adaption procedure will be used to align cell faces with dominant flow features, which will improve the resolution of solutions obtained using standard grid-aligned flow solvers. Phase I will demonstrate the feasibility of the approach as a means to improve the efficiency and accuracy of numerical methods for the equations of fluid flow.

Potential Commercial Applications: This project promises to improve accuracy and efficiency of existing numerical methods used in high technology industry.

***

013 ARC
92-1-02.01-1700 NAS02-13801
Wavelet Methods for the Compressible Euler and Navier-Stokes Equations
Aware, Inc.
One Memorial Drive
Cambridge, MA 02142
John Weiss (617-577-1700)

The firm has developed a wavelet-based method for the solution of boundary value problems in arbitrary geometries. This method (wavelet capacitance method) is defined by a non-trivial extension of the classical capacitance matrix method, and unlike the classical method, can be spectrally accurate. This project will develop Wavelet-Galerkin and pseudo-Galerkin algorithms for the compressible Euler and Navier-Stokes equations in an arbitrary (smooth) domain. The firm will conduct a detailed comparison of the pseudo-Galerkin wavelet algorithm and the algorithm based on the standard Wavelet-Galerkin method. A preliminary study of two-dimensional compressible flows, for a range of Mach and Reynolds numbers, will also be conducted using wavelet methods.

Potential Commercial Applications: If, as the preliminary results indicate, wavelet methods can properly resolve shocks, turbulence, and discontinuities at interfaces, then it will be possible to incorporate the effects into the engineering process.

***

014 ARC
92-1-02.01-3688 NAS02-13796
A Pseudo-Spectral Mapping Technique for the Accurate Solution of Viscous Flows in Complex Geometries
Dynaflow, Inc.
7210 Pindell School Road
Fulton, MD 20759
R. Duraiswami (301-604-3688)

The fundamental understanding of many fluid flow phenomena would be greatly enhanced if it were possible to simulate fluid flow in complex geometries with high resolution. The spectral method has been used successfully for this purpose in simpler geometries. This project will combine the spectral method with an orthogonal-mapping-grid-generation method, based on the theory of quasi-conformal mappings, to simulate viscous fluid flow in complex geometries. This approach offers order-of-magnitude advantages in accuracy and speed over conventional methods for solving such problems, reduces errors in boundary condition representation, and is suited to the solution of nonlinear problems. Phase I will develop a computer code based on this approach and apply it to the problem of viscous flow past a cavity of complex shape. Phase II will concentrate on the further extension and application of the code to more complicated flows, including free-surface flows, and on the development of a user-friendly commercializable code, with pre- and post-processing features.

Potential Commercial Applications: The computer code will be useful to private industry, research laboratories, and federal agencies to simulate flows in many areas of aerodynamics, including coating-flows, free-surface flows, flow in pipes of complicated cross-section, and biological flows.

***

015 ARC
92-1-02.01-9457 NAS02-13794
Advanced Discretization Algorithm for Computational Fluid Dynamics Methods
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Robert E. Childs (415-968-9457)

This project concerns high-accuracy, shock-capturing differencing algorithms. Theory indicates that the advanced eighth-order method can reduce by a factor of about 100 the number of grid points required for accurate discretization of complex three-dimensional flows when compared to typical second-order methods. The objective of this project is to determine if the theoretical improvement is attained in relevant flows and to address issues concerning the implementation of high-accuracy methods in modern computational fluid dynamics (CFD) codes. These issues will be resolved through analysis and calculations of model problems.

Potential Commercial Applications: CFD is used by NASA and a wide range of commercial firms in the aerospace, automotive, and electronics industries. Improved CFD methods will benefit NASA and these industries by providing more accurate and less costly research, development, and design methodologies.

***

016 LaRC
92-1-02.02-0818 NAS01-19917
Transition Prediction and Laminar Flow Control in Compressible Three-Dimensional Boundary Layers Using Parabolized Stability Equations
High Technology Corporation
28 Research Drive
Hampton, VA 23666
Mujeeb R. Malik (804-865-0818)

This project will develop a transition prediction code for three-dimensional compressible boundary layers. The code will be based upon the parabolized stability equations (PSE) approach and could be used both for subsonic and supersonic flows. Since the PSE approach allows nonparallel as well as nonlinear effects, it can properly account for wave interactions and could be used for transition control studies including localized control through either mean flow alteration or intelligent control using neural networks.

Potential Commercial Applications: The computer code can be used as a design tool for NASA's laminar flow control program and can be applied to subsonic aircraft as well as high speed civil transport

***

017 ARC
92-1-02.03-2299 NAS02-13799
Laser-Based Instrument for Nonintrusive Diagnostics of Hypersonic Reactive Flows
Schwartz Electro-Optics, Inc.
45 Winthrop Street
Concord, MA 01742
Glen A. Rines (508-371-2299)

A new, laser-based, non-intrusive diagnostic instrument will be developed for use in the study of hypersonic flows and supersonic combustion processes. The instrument is comprised of a single-frequency, high-energy, titanium-sapphire laser and high-resolution, atomic resonance filters (ARFs). Phase I will develop robust control-electronics hardware for maintaining single-frequency operation of the titanium-sapphire laser and will measure with high spectral resolution and high precision the absorption features of a mercury-vapor ARF. This instrumentation will make possible a wide range of new spectroscopic techniques, ultimately allowing accurate two-dimensional and three-dimensional measurements of scalar fields such as temperature, pressure, and species concentrations (atomic, molecular, and radical), and vector fields such as velocity and vorticity. These measurement capabilities are critical to the future development of sophisticated supersonic and hypersonic aircraft.

Potential Commercial Applications: The instrumentation developed under this program will have applications as a commercial scientific laser system for use in basic investigations of atomic, molecular, and radical species which are not necessarily in high-speed flows, in particular, microgravity combustion diagnostics and environmental remote-sensing applications.

***

018 ARC
92-1-02.03-4471 NAS02-13798
High-Resolution Solutions to Stiff, Chemically Reacting Flow Fields
Enig Association, Inc.
11120 New Hampshire Avenue, Suite 500
Silver Spring, MD 20705-2633
Jacob Krispin (301-593-4471)

This project will develop a state-of-the-art, second-order accurate (hybrid, implicit-explicit, directionally unsplit, Godunov-type), time-dependent scheme capable of solving high-temperature, viscous, nonequilibrium, chemically reacting, and, possibly, two-phase flow fields. The new scheme will be developed to the point that realistic aerodynamic design and analysis simulations, including the relevant aerothermodynamic flow fields, can be calculated. Phase I will use a two-dimensional, directionally unsplit, inviscid version of the scheme to solve for stiff, chemically reacting model problems, implementing and testing ideas recently published about high-order Godunov Schemes.

Potential Commercial Applications: The code will provide an optimal tool for the analysis of material structures, aerodynamic designs, propulsion and performance analysis of hypersonic vehicles.

***

019 LaRC
92-1-02.03-5630B NAS01-19879
Simultaneous Density and Velocity Measurements in Hypersonic Flow
Complere, Inc.
P.O. Box 1697
Palo Alto, CA 94302
F. Kevin Owen (415-321-5630)

While diagnostic tools are available to attempt the measurement of turbulent hypersonic flows, few comprehensive studies of these tools have been conducted. Moreover, comparisons of new laser velocimeter turbulence measurements with previous hot wire results indicate that past data reduction assumptions can result in significant measurement errors in hypersonic flows. Extensive work is needed to establish a reliable data base for turbulence modeling. This project will search

for a new concept for the simultaneous, real-time measurement of density and velocity and the compressible shear-stress terms.

Potential Commercial Applications: This new instrument will potentially provide for advanced flow field diagnostics of compressible flows. These new measurements will improve comprehension of both the physics and the structure of turbulence in high speed flows which can be used to develop empirical turbulence models and to validate Navier-Stokes codes.

***

020 LaRC
92-1-02.03-5630D NAS01-19874
Measurement of Aerobrake Model Forces and Flow Fields
Complere, Inc.
P.O. Box 1697
Palo Alto, CA 94302
F. Kevin Owen (415-321-5630)

Aero-assisted space transfer vehicles have three primary components: the aerobrake, the payload, and the propulsion unit. Flow field interaction with and between these elements can have significant effects on vehicle stability and allowable payload size and shape. Of particular importance is the interaction of the near wake with the payload compartment. In consequence, precise determination of wake structure and closure is a critical issue for aerobrake design. The heating and aerodynamic forces that may result from the interactions between the payload and near wake are not well understood. Additionally, available experimental data is not sufficient to validate CFD models and may be contaminated to unknown degrees by sting interference or model wire suspension effects. This project's goal will be to develop innovative magnetic model suspension and flow field instrumentation to support code validation efforts.

Potential Commercial Applications: Improved magnetic suspension balance and flow field measurement systems for rarefied flows will contribute to the national space program by providing data that will help establish a sound technological foundation for the cost-effective design of future aero-assisted space transfer vehicles.

***

021 ARC
92-1-02.04-1400 NAS02-13781
A Leading Edge Extension Blowing Concept for Enhanced High-Alpha and Post-Stall Aerodynamics of Highly Maneuverable Configurations
Vigyan, Inc.
30 Research Drive
Hampton, VA 23666-1325
D.M. Rao (804-865-1400)

Leading edge extensions (LEXs) are proven, passive, vortical devices for improving the $C_{L,max}$ capability of thin, low aspect-ratio wings. With the onset of vortex breakdown, severe pitch-up and roll/yaw asymmetries develop in conjunction with lift loss, making the configuration prone to departure. To alleviate these undesirable post-stall aerodynamic characteristics, actively controlled LEX concepts are needed where the vortical growth and interaction with airframe surfaces may be controlled independently of angles-of-attack and sideslip. A pneumatic approach to LEX vortex control will be developed using spanwise ejection from LEX leading-edge slots, both to augment the LEX vortices and to laterally displace them on wings for improved aerodynamic interactions in the post-stall regime. The concept incorporates non-symmetrical blowing for lateral control. Associated potential benefits include pitch-down, yaw control, and tail-buffet alleviation. Following successful preliminary explorations, a low-speed wind tunnel test program will be conducted on a generic complete aircraft configuration aimed at detailed evaluations of LEX slot geometry and momentum distributions to determine the best aerodynamic effectiveness at practical blowing rates. Additionally, six-component force-moment measurements and flow visualizations will be performed, and the LEX blowing effects on the vertical tail buffet will be monitored.

Potential Commercial Applications: This project will contribute significantly to the NASA High-Alpha R&D programs and benefit the military aircraft industry in its design concepts for future highly-maneuverable tactical vehicles.

***

022 ARC
92-1-02.04-3304 NAS02-13789
A Hybrid Structured-Unstructured Grid-Implicit Algorithm for Geometrically Complex Flow Fields
Amtec Engineering, Inc.
P.O. Box 3633
Bellevue, WA 98009-3633
Moeljo Soetrisno (206-827-3304)

Currently, structured-grid algorithms for solutions of the Navier-Stokes equations are particularly efficient but are restricted in their geometric flexibility. Unlike structured-grid methods, unstructured-grid methods can easily treat complex geometry configurations but have been found to be inefficient in viscous-dominated regions such as boundary layers because of the long, thin control volumes often countered in the boundary layer and the treatment of turbulence models. Therefore, the geometric flexibility of the unstructured-grid methods should be combined with the numerical accuracy and efficiency of the structured-grid methods. Hybrid methods can be used to efficiently obtain solutions for geometrically complex flow fields. This project will develop an efficient zonal-implicit algorithm for hybrid structured-unstructured grids. The research will focus on implicit techniques for solving the Navier-Stokes equa-

tions on unstructured finite-volume grids and for zonal coupling between structured and unstructured grids. The zonal approach gives the user full control of the regions where unstructured-structured grids are applied. Phase I results will demonstrate the hybrid approach and Phase II will implement this approach in a production-version, three-dimensional Navier-Stokes code for solutions of complex configurations.

Potential Commercial Applications: The hybrid structured-unstructured grid-implicit algorithm results in both the geometric flexibility of unstructured grids for easy mesh generation and the numerical maturity and efficiency of structure-grids for complex flow physics. The code can be used efficiently as both a design and an analysis tool and will find a ready market in the aerospace industry and other industries.

***

023 LaRC
92-1-02.05-7093 NAS01-19918
High-Alpha, Unsteady Surface-Flow, Diagnostic Tool for Aircraft Dynamics
Analytical Services & Materials, Inc.
107 Research Drive
Hampton, VA 23666
Siva M. Mangalam (804-865-7093)

An innovative high-alpha, unsteady flow, diagnostic tool incorporating advanced flow sensors, instrumentation, and surface-flow signature analysis, will be developed for investigating dynamic stall. Phase I will investigate high-alpha flow dynamics in wind tunnel tests. Unsteady pitch motions will be imparted to a model instrumented with multi-element hot-film sensors. Signature analysis of simultaneously acquired signals from multiple sensors will be used to capture post-stall flow characteristics such as the location of the instantaneous' stagnation, separation, and reattachment points and their associated unsteadiness (frequency), thus allowing the demarcation of unsteady flow separation regions. Phase II will test and develop a flight-validated, unsteady-flow diagnostics tool capable of describing dynamic stall characteristics and establishing a technical design data base for unsteady aircraft dynamics, simulation, and control applications.

Potential Commercial Applications: A flightworthy, integrated, unsteady-flow diagnostic tool capable of describing dynamic stall characteristics will find a ready market in organizations involved in aircraft design, manufacture, testing, and the validation of computational tools.

***

024 ARC
92-1-02.06-2021 NAS02-13785
A Unified Numerical Approach for Rotorcraft Aerodynamics
Flow Analysis, Inc.
256 93rd Street
Brooklyn, NY 11212
Clin M. Wang (718-875-2021)

A new vorticity confinement method, which has been demonstrated to convect vorticity on a coarse grid without excessive numerical diffusion, is to be incorporated into an efficient viscous flow solver to resolve complicated flow problems encountered in rotorcrafts. The accuracy and the efficiency of the new combined numerical approach will be demonstrated through pilot computations of retreating blade dynamic stall and strong blade-vortex interaction, including vortex impingement. The new code will be able to treat realistic rotorcraft-type flows with concentrated, thin vortical regions, as well as flows that may involve continuous shedding of vorticity from the blade.

Potential Commercial Applications: The new code will be efficient and accurate for solving vortex dominated flows. These flows are involved in many different applications, including problems encountered by the aerospace industry and by builders of wind-mills, ships, and automobiles.

***

025 LaRC
92-1-02.07-0204 NAS01-19906
Imaging Radiometer for the Characterization of Boundary Layer Phenomena
SSG, Inc.
150 Bear Hill Road
Waltham, MA 02154
Wallace K. Wong (617-890-0204)

The critical boundary layer condition between laminar and turbulent flow over an airfoil area is indicated by extremely small temperature differences (a noise-equivalent ΔT of .1°C). The complexity of the measurement problem is dramatically increased by the 100 K ambient temperature and the need for a non-perturbing technique. The core innovation is the exploitation of wide-spectral band, cryogenic optical systems, and commercial, mosaic plane focal array technologies in a unique, calibratable imaging radiometer operating at 100 K. The focal plane array (FPA) is an Si:Ga array with response to 18 μm which uses the long wavelength radiation emitted by the cold surface. Phase I trade studies will determine the optimum combination of spatial resolution, noise-equivalent ΔT, field of regard, and instrument size with the fixed FPA configuration to best meet the sensor requirements. Upon their completion, a preliminary optical design and a conceptual system design will be performed, and a prototype optical system will be developed. The system will provide the desired sensitivity increase in airfoil testing and permit

improved design of high-speed aircraft and high-altitude vehicles. The concept is applicable to any remote, high sensitivity, wide-spectral radiometric measurement application operating over a wide range of ambient temperatures.

Potential Commercial Applications: The concept applies to calibrated radiometric measurement applications, including design of commercial aircraft and space vehicles, transfer calibration of radiometric standards and sensors, and testing of high sensitivity, low background focal plane arrays.

***

026 LaRC
92-1-02.07-7093 NAS01-19919
A High Sensitivity, Large Bandwidth Constant Voltage Anemometer for Speed Transition Research
Analytical Services & Materials, Inc.
107 Research Drive
Hampton, VA 23666
Siva M. Mangalam (804-865-7093)

A new approach will be developed to measure low-amplitude, high-frequency flow fluctuations which lead to high-speed boundary-layer transition in low-disturbance (quiet) wind tunnels. The constant voltage anemometer (CVA) concept provides large bandwidths with high sensitivity. Preliminary studies at low speeds have shown that the CVA holds significant promise for high-speed applications. During Phase I, a prototype device will be built and tested in high-speed wind tunnels, and the results will be compared with data obtained under identical test conditions using conventional instrumentation. Because conventional anemometers have limited bandwidth and low signal-to-noise ratio at high frequencies, independent tests will be conducted to establish the bandwidth of the CVA. Concurrently, theoretical analysis will be carried out to establish the relationship between the output signals of the CVA and the physical flow parameters. During Phase II, the CVA will be used to study attachment-line instability and transition on a swept-wing model. These studies will be used to establish the design parameters and operational characteristics of the CVA for research and commercial applications.

Potential Commercial Applications: The development of this device will meet the demand for high-sensitivity, large-bandwidth thermal anemometers needed for high-speed dynamic flow measurements. The CVA will find commercial applications in all national and international organizations involved in flow measurements.

***

027 LaRC
92-1-02.08-2100 NAS01-19894
High-Temperature, Fiber-Optic Pressure Sensor
OPTRA, Inc.
461 Boston Street
Topsfield, MA 01983-1290
Andrew Lintz (508-887-6600)

The goal of this project is to develop a fiber-optic pressure sensor suitable for use in temperatures up to 1500 K. The five-millimeter-diameter sensor head consists of a sapphire sensing element and a single-mode, high-birefringence fiber optic link to the remote phase-processing electronics. The sensor interferometrically measures the displacement of a thin sapphire diaphragm that responds to pressure (0 - 50 psi) with a bandwidth of greater than 25 kHz over a wide temperature range (300 K - 1500 K). This sensor introduces the use of an electro-optic modulator to heterodyne the pressure signal and eliminate the temperature sensitivity of the fiber. It also uses a robust interferometric phase measurement technique that, unlike conventional interferometric sensors, is linear at any operating point and immune to fluctuations in laser power or fringe visibility.

Potential Commercial Applications: This measurement system is characterized by ruggedness, absolute calibration, freedom from electrical interference, remote processing through fiber optic linkage, and the ability to operate over a very high temperature range and bandwidth. Initial commercial applications will involve either measurements in relatively inaccessible or hazardous environments such as chemical process control and combustion or specialized applications involving extreme temperatures.

***

028 LaRC
92-1-02.08-6100 NAS01-19887
Miniature Laser Velocimeter
Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303
Pajo Vujkovic Cvijin (415-493-6100)

This project will build a laser-Doppler velocimeter with sufficient accuracy and resolution to allow boundary-layer measurement. The objective will be to design, build, and test a first-of-its-kind velocimeter based on frequency stabilized diode lasers and monostatic heterodyne technology. The instrument will surpass the performance of other laser-Doppler velocimetry (LDV) techniques and have important advantages over its competition related to its size, cost, lifetime, and ruggedness. The design presented here is optimized for boundary-layer flow measurement in wind tunnels. Phase I will set up the first model of the system and measure the critical problem of flare and other operational parameters related to wind tunnel application. Phase II will engineer and construct a prototype system,

install it on the 16-foot wind tunnel at NASA Langley Research Center, and demonstrate its performance.

Potential Commercial Applications: The immediate application of the instrument will be for boundary-layer flow measurement in wind tunnels, fulfilling a critical need in aerodynamic measurement by optical means. Commercial application for this low-cost technology includes other areas of wind tunnel testing, air data measurement in aircraft, and production control for sheet material.

***

029 LaRC
92-1-02.09-9282 NAS01-19880
Computational Methods for Rotor Transonic, Aeroacoustic-Aeroelastic Analyses
Continuum Dynamics, Inc.
P.O. Box 3073
Princeton, NJ 08543
Todd R. Quackenbush (609-734-9282)

Advanced aeroacoustic analysis is required for the study of high-speed rotorcraft. Extensions of existing tools can address many important problems in rotor noise analysis, but prediction of both unsteady loading and shock noise on rotors with transonic blade tips requires the application of sophisticated flow solvers. Additionally, recent work has identified the sensitivity of rotor and propeller noise to structural deformation and to shock wave strength and position. New techniques to address such problems can be developed by using modern flow-field analysis codes along with a new approach to fluid-structure coupling. This approach involves a mixed Eulerian-Lagrangian formulation of the Euler equations on a moving mesh in which the equations governing the fluid and structure are advanced simultaneously in a way that greatly increases the accuracy of the computed energy exchange between the two media. This project investigates the feasibility of coupling this approach with the RotorCRAFT comprehensive rotor analysis software to produce surface loading and shock characteristics for use in rotor noise computations. The project will also assess the advantages of the new formulation and lay the groundwork for an advanced analysis of computational aeroelasticity for the study of high-speed rotorcraft aeroacoustics.

Potential Commercial Applications: The principal benefit to commercial licensors of this technology will be the ability to analyze and design low-noise tiltrotors and helicopters that will satisfy the requirements of potential customers for both civil and military applications.

***

030 LeRC
92-1-02.10-7070 NAS03-26720
Auxiliary Jet Impingement to Reduce Jet Noise
Aerochem Research Laboratories, Inc.
P.O. Box 12
Princeton, NJ 08542
Charles H. Berman (609-921-7070)

Supersonic jet noise will be reduced by using small auxiliary jets to impinge on the main noise producing jet, causing it to mix faster with the ambient fluid and reduce its velocity. The idea for the innovation is based on low Reynolds number, supersonic tests performed at AeroChem which demonstrated improved mixing. The main objective of Phase I is to verify that the innovation is beneficial at higher Reynolds number and in a general range of parameters that would indicate that the concept would be relevant for jet engines. An experimental program will determine the degree of enhanced mixing caused by the impinging jets for different density supersonic jets and for a subsonic jet. The results will determine basic parametric dependencies for improved mixing that will be used to plan the Phase II program and assess the potential applicability to jet engine noise reduction. The results of the program will benefit NASA in its programs related to noise reduction of supersonic jets.

Potential Commercial Applications: The direct application is in support of jet noise reduction for high exhaust velocity engines such as planned for the high speed civil transport. Other applications are in the combustion and chemical process industries where rapid mixing of different reactant streams is often needed.

***

03: Aircraft Systems, Subsystems, and Operations

031 LeRC
92-1-03.01-0202 NAS03-26719
Aircraft Ice Detection System
Axiomatics Corporation
3G Gill Street
Woburn, MA 01801
Frank A. Waldman (617-932-0202)

This project addresses the need for a dielectric sensor technology to detect, quantify, and characterize ice accretion on aircraft components both in-flight and on the ground. A prototype apparatus will be designed to measure accurately the thickness of varying layers of water, deicing fluid, and ice-based on a shunting dielectric sensor. Sensor response to varying thicknesses of water, deicing fluid and ice, as well as mixtures of these three components, will be characterized. An algorithm will be developed for the thickness of ice over the sensor, including ice formed over a deicing layer, and verified using the test apparatus across a representative temperature range. The system could

provide a low-cost, low-power, retrofittable ice detection capability that could serve as a primary control for in-flight activation of an ice protection system, minimize deicing required at the ramp, while providing verifiable aircraft protection and maximizing holdover times. In addition, the system could provide valuable real-time data on advanced ice protection concepts as part of NASA's Aircraft Icing Technology Program.

Potential Commercial Applications: This aircraft ice detection system has the potential for eliminating the danger of clear ice in-flight. The system can also be used by airlines and airport operators for ramp deicing, and will both improve on its effectiveness and minimize the environmentally harmful discharge of deicing fluids into watersheds.

***

032 LaRC
92-1-03.02-8157B NAS01-19907
Detection of Wake Vortices at Airport Runways
Turbulence Prediction Systems
3131 Indian Road
Boulder, CO 80301
Charles F. Morrison (303-443-8157)

A passive infrared (IR) method will be developed for detecting and monitoring wake vortices in the vicinity of runways. To establish a safe, fundamental method for detecting and monitoring wake vortices is crucial for increasing both flight safety and airport efficiency. The effort consists of modifying existing equipment for recording IR, weather conditions, and aircraft type at a commercial runway under a range of weather conditions; creating an analysis format and analyzing the data; and developing a method for wake vortex detection and monitoring. The anticipated results will show that IR is a capable tool for the measurement of vortices from commercial aircraft and that weather conditions will cause significant differences in wake-vortex behavior with modifications for aircraft type.

Potential Commercial Applications: Both airport efficiency and aircraft safety can be gained with this technology. All airports with moderate and heavy aircraft traffic could use the IR-based, wake-vortex system. Pilots will be able to optimize the flight path for interactions with wake vortices and to avoid dangerous runway situations.

***

033 LaRC
92-1-03.02-8736 NAS01-19878
Monitoring Weather Effects on Aircraft Wakes Using a Solid-State Coherent Lidar
Coherent Technologies, Inc.
P.O. Box 7488
Boulder, CO 80306
Stephen M. Hannon (303-449-8736)

A pulsed, coherent, two-micron lidar for monitoring the persistence and decay of aircraft vortex wakes in the airport terminal environment and for relating the wake history to the local weather will be explored. The volume monitored is to be large enough to enable monitoring of the ambient wind patterns at scales that affect vortex wake transport and persistence. The goal of this project is to use the high resolution capability of lidar to enable simultaneous monitoring of the vortex dynamics, as well as of the wind field environment in which the wake is embedded. Such data will allow validation and extension of vortex transport models and decay, as well as providing a direct link between data available from large-scale, wind-field measuring systems and the vortex hazard at airports. Detailed computer simulations of the coherent lidar wind and wake vortex measurement process will be used to determine the capability of a ground-based, two-micron coherent lidar for the detection and measurement of landing corridor winds and wake vortex velocities. An existing 2.09-micron, pulsed, coherent lidar will be taken to an airport to obtain experimental velocity data on wake vortices and measurement of landing corridor winds.

Potential Commercial Applications: Commercial applications will be for airport terminal area surveillance for wake vortices, winds in the airport area, and microburst windshear. This technology is also applicable for on-board airliner windshear detection.

***

034 LaRC
92-1-03.03-0249 NAS01-19883
Integrated Criteria and Synthesis for Multivariable Flight Control
EGR Association
8401 Ericson Drive
Buffalo, NY 14221
Edmund G. Rynaski (716-634-0249)

New high performance aircraft configurations, such as hypersonic vehicles, flying wing, oblique wing, and vehicles designed for high angle-of-attack operation, have incorporated the use of unique and often redundant control effectors such as canards, thrust vectoring, and split rudders or ailerons. This project will show that the control criteria or pilot-vehicle interface requirements can be integrated or imbedded into the methods of modern, powerful, control system synthesis to yield multivariable flight control system configurations that will enable the pilot to fly with enhanced precision, ease, and confidence. Phase I will demonstrate that the weighting matrices of a linear, quadratic regulator design can be chosen to satisfy flying qualities requirements of an angle-of-attack command and other "response type" systems. This project will seek adequate and accurate control of unique vehicle geometries such as the oblique wing, wingless, and national aerospace plan (NASP) vehicle configurations.

Potential Commercial Applications: Multivariable control theoretic methods, when properly applied, will result in systems that greatly improve manual flight precision.

***

035 LaRC
92-1-03.03-3474 NAS01-19877
Knowledge-Based Neural Flight Control System
Charles River Analytics, Inc.
55 Wheeler Street
Cambridge, MA 02138
Greg L. Zacharias (617-491-3474)

Phase I will explore the development of a hybrid knowledge-based neural flight control system (FCS) for high-performance aircraft. The goal of this project is to integrate two complementary technologies: artificial neural networks (ANNs) and knowledge-based expert systems (ESs). ANNs can offer several advantages to FCS design: rapidly adaptable on-line solutions; productivity improvements in the off-line design process; implementation efficiency on emerging neural computers; and hardware fault-tolerance. ESs can also offer advantages to FCS design: knowledge-based executive control and mode-switching of the FCS, direct implementation of existing algorithmic control solutions, and support of on-line learning via an embedded ANN knowledge base. This project will develop a hybrid of neural control and knowledge-based expert control. An FCS prototype using a commercially-available ANN-ES development tool, NueX, which provides a graphical user interface for ANN specification, an object-oriented ES shell for knowledge-base development, and C-code linkages for control algorithm implementation, will be developed. Following development, a feasibility demonstration will be conducted with a limited-scope simulation over different flight conditions and operating control modes.

Potential Commercial Applications: Commercial potential exists for the end product itself, a hybrid FCS design for high performance aircraft, and for the hybrid software environment use to develop it. The FCS design holds promise for incorporation in a wide range of existing and advanced aerospace systems. The development software has generic applications in complex control design problems in the industrial, medical, and process control areas.

***

036 LaRC
92-1-03.05-0997 NAS01-19899
Aircraft-Based Fiber Optic Environmental Sensor Network
Optiphase, Inc.
7652 Haskell Avenue
Van Nuys, CA 91406
Ira Jeffrey Bush (818-782-0997)

This project addresses the development of a generic fiber optic distributed sensor system for sensing aircraft pressure and temperature and atmospheric conditions. The system employs optical, high-precision, passive interferometric transducers which are time-domain multiplexed on a fiber-optic network. The fiber-optic network is a single mode, generic, multi-tap architecture and provides a standard connection interface to any type of sensor. This concept can be generalized to sensors that respond to temperature, pressure, strain, position, acoustics, acceleration and vibration. Phase I will define and analyze the performance of the overall network, including the central optical and signal processing function, telemetry system, and passive sensor types. Interferometric sensors for pressure, temperature, and atmospheric conditions will be conceptually designed and evaluated for performance. Laboratory experimentation will be conducted to verify concepts. An optimum configuration will be selected from the design phase and will be the basis for the Phase II engineering development.

Potential Commercial Applications: Many markets in both the military and commercial sectors need a lightweight, passive distributed sensor system, including air and/or spaceborne sensing systems. Generic sensing systems, employing interchangeable sensor functions that diagnose the overall status of complex platforms, will standardize the diagnostic interface and greatly enhance the diversity of applications addressed as well as reduce the development cost of such systems.

***

037 ARC
92-1-03.05-8157 NAS02-13731
Airborne, Remote Sensing of Turbulent Air Motion
Turbulence Prediction Systems
3131 Indian Road
Boulder, CO 80301
Frederick C. Wilshusen (303-443-8157)

An active infrared (IR) instrument that provides three-dimensional information for use in the monitoring and study of atmospheric turbulence will be developed. The innovation overcomes the limitations that prevent the satisfactory use of present gauging technology. The objective is to establish that a practical laser can drive the system at 10 meters and that the physics is sufficiently unique to provide accurate measurements. The project will seek to generate computer models that combine the laser physics, IR physics, airspeed, and three-dimensional wind for use in concept testing and parameter definition. It will study IR laser power transfer to the air and IR sensitivity properties to detect the same. Additionally, it will determine the practical size for the combined instrument in research aircraft. It is anticipated that a practical device can be developed which would measure three-dimensional wind speeds to well below 1 m/s with 5 percent or better accuracy.

Potential Commercial Applications: Expected NASA applications and benefits are an opportunity to measure accurately three-dimensional air motion from a moving aircraft. Other possible applications include remote turbulence detection (from aircraft or ground-based), and wake vortex detection (airborne or ground-based).

***

038 ARC
92-1-03.06-0003 NAS02-13730
Compact Diode-Laser-Based Inlet and Exhaust Mass-Flow Flight Instrument
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Mark G. Allen (508-689-0003)

Recent advances in compact, tunable, room-temperature, diode lasers now permit sensitive measurement of gas dynamic properties with low-power, small-volume, low-cost instrumentation. Currently, laboratory demonstrations of path-averaged density and velocity measurements in flows depend on high-frequency modulation techniques to achieve the required sensitivity for practical, in-flight applications. This project addresses a new concept for ultra-sensitive, mass-flux measurements using a novel detection system that eliminates the need for complex, high-bandwidth modulation and detection strategies. Shot-noise-limited sensitivity is achieved using conventional detectors and amplifiers in a novel transistor-pair combination. Inlet mass flux is determined from simultaneous, non-intrusive O_2 density and velocity measurements. Exhaust mass flux is determined from combined O_2 and H_2O measurements. The two measurements are determined to form a real-time thrust determination. Phase I will demonstrate the sensitivity required for typical flight conditions with typical absorption path lengths and optical access limitations. This data will be used to complete a preliminary design of a prototype brassboard instrument. Phase II will develop and test the prototype in a simulation facility at the company.

Potential Commercial Applications: The mass-flux monitor is expected to have a broad commercial application in the civilian and defense aerospace industry. In addition, the ultra-sensitive detection system will be applicable to a wide range of gas emission monitoring systems.

***

039 ARC
92-1-03.06-0540 NAS02-13732
Electromagnetic Shaker for Aircraft Structural Characterization
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Richard L. Hockney (617-661-0540)

This project will design, fabricate, and demonstrate an electro-mechanical seismic shaker for aircraft flight testing. The shaker, which could be quickly and easily attached to wing-tip accessory rails, would allow dynamic flight characterization of existing aircraft. This device is needed because existing methods utilizing natural turbulence are too slow and incorporation of hydraulic seismic shakers into existing aircraft is prohibitively expensive. The concept, which has been made possible by new developments in motors and solid-state power conversion, will incorporate a unique linear induction motor driven by a resonant converter operating at 20 kHz. The resonant converter uses pulse-population-density modulation to operate the induction motor as an extremely power dense and efficient, four-quadrant, variable-speed actuator. The pulse-population-density modulation approach provides inherent electromagnetic-interference (EMI) suppression while minimizing required filtering and shielding. The project will result in a flight-certifiable design having a combination of small-size, low EMI, and low harmonic levels not previously possible in electro-mechanical seismic shakers. Phase I will provide a preliminary design and Phase II will construct a prototype unit for testing.

Potential Commercial Applications: This product will substantially reduce the cost and decrease the time required for dynamic flight testing of existing aircraft. It is anticipated that there will be a substantial market for a lightweight, low cost shaker system which can be employed in testing experimental, military, and commercial aircraft.

***

040 LaRC
92-1-03.07-2620 NAS01-19869
Graphical User Interface for Design of Hypersonic Vehicles
Adaptive Research Corporation
4960 Corporate Drive, Suite 100A
Huntsville, AL 35805
John F. Stalnaker (205-830-2620)

Development of a user-friendly graphical interface linking existing engineering computer programs for optimization of future hypersonic vehicle concepts is the goal of this project. Phase I will develop this interface for SRGULL, a suite of engineering codes developed by NASA for prediction of the integrated performance of national aerospace plan (NASP) configurations. SRGULL is an interactive engineering tool capable of nose-to-tail modeling of NASP components for rapid generation of initial estimates of vehicle engine performance. The emphasis in Phase I will be the development of CAD-like software to provide a higher and more sophisticated degree of automation of the SRGULL code. A significant strength of the present approach is the modular nature of the interface which allows upgrades to more advanced grid generation techniques, including unstructured grids, grid quality measures, and solution adaptive procedures. Phase II will result in a

super workstation-based aerodynamic and engine performance simulator with powerful engineering computer programs linked together by customized pre- and post-processors. The menu-driven interface will be versatile enough to allow user customization, modification, or replacement of existing engineering models. Progressively higher fidelity analyses could be performed in an engineering design environment on secure, inexpensive machines quickly and efficiently, thus saving valuable engineering resources and speeding the design process. The time required to become proficient in the use of these engineering design tools would also be greatly reduced.

Potential Commercial Applications: Graphical user interfaces will ultimately become the standard as the level of computational sophistication and user flexibility increases. The interface will thus make computational fluid dynamics design tools, in general, much more accessible and attractive to many industries which would otherwise not foster such expertise. The automotive, chemical, electronics, environmental, marine, and power industries all offer high potential for commercial applications.

***

041 LaRC
92-1-03.07-2900 NAS01-19875
A Novel Hydrogen-Fueled Propulsion System
Adroit Systems, Inc.
209 Madison Street, Suite 500
Alexandria, VA 22314
Thomas R.A. Bussing (703-684-2900)

Currently, airbreathing propulsion systems which operate in the subsonic to low hypersonic regimes are expensive, complex and heavy. To overcome these limitations, a novel propulsion concept, based on a hydrogen-fueled pulse detonation engine (PDE), will be developed. The innovation draws from recent successes in computational fluid dynamics and from several recent engineering studies. The propulsion system will have a very low unit cost, design simplicity and operational simplicity. Its many features will include the ability to operate over a range of Mach numbers, the potential to operate in a pure rocket mode, and the capability for propelling a variety of high speed and transatmospheric vehicles.

Potential Commercial Applications: Commercial applications include propulsion for research vehicles, innovative power generation devices, and elements of novel, commercial, earth-to-orbit launch vehicles.

***

042 ARC
92-1-03.08-3200 NAS02-13782
Lightweight, High-Strength PBO Structures for High-Altitude Subsonic Aircraft
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Leslie S. Rubin (617-890-3200)

The specific strength and stiffness of high-altitude subsonic aircraft structures can be significantly improved through the use of lyotropic crystal polymers (LCPs). In Phase I, an advanced LCP, polybenzoxazole (PBO) and a new generation LCP extrusion die will be used to produce lightweight and high strength honeycomb cores. These cores will permit the manufacturing of aircraft wings suitable for extended subsonic flight above 70,000 feet. The PBO cores are expected to have specific properties that are two-to-four times higher than today's leading lightweight structural cores. Phase I will initially concentrate on the fabrication and modification of a new generation of biaxially oriented PBO film which exhibits significantly higher quasi-isotropic properties than has been achievable to date. Protocols for fabricating film-based PBO honeycomb cores will then be established by Hexcel, a leading manufacturer of honeycomb core structural materials. The project will conclude with the fabrication, testing and analysis of prototype PBO honeycomb cores.

Potential Commercial Applications: The successful development of the lightweight, high-strength structures and their commercialization by Hexcel will enable NASA to fabricate high altitude (>70,000 feet) subsonic aircraft that can more effectively perform global climate research. This technology will have special commercial research appeal for the aircraft industry to improve fuel efficiency, and the refrigerator industry to manufacture better insulating materials. The advanced materials created by this technology will also find a ready commercial market with sports equipment manufacturers.

***

043 ARC
92-1-03.08-8457 NAS02-13786
Facultative, Hypergolic-Ignition, Internal Combustion Engine
Alvin Lowi & Association
2146 Toscanini Drive
San Pedro, CA 90732
Alvin Lowi, Jr. (310-548-8457)

The firm will conduct an analytical investigation to establish technical support for a facultative internal combustion engine suitable for the prop-drive propulsion of very-high-altitude, unmanned atmospheric research aircraft. The engine would be fully functional with or without aspiration and would not require air for cooling, thereby rendering unnecessary the use of heavy and drag-producing accessories customarily required for high altitude aspiration and cooling. With the ability to

efficiently utilize available air, the consumption of expendables would be minimized during climbing, thus improving payload, range, and/or endurance. In addition, a compact, lightweight, small frontal area engine will be designed that will be fully balanced, while delivering exceptional high torque at low shaft speeds with a minimum of shaking or torsional vibration, and will be capable of delivering its full rating at any altitude. This project will also investigate the state-of-the-art of hypergolic ignition and facultative combustion as applied to a novel internal combustion engine design. Estimates will be made of the structural, thermal, and dynamic loadings which would prevail in a non-metallic, passively cooled, axial piston engine. Some of the vehicle integration factors such as the vibration, weight, temperature distribution, and consumables.

Potential Commercial Applications: The powerplant's high power density, low vibration, and hypergolic combustion process make it an ideal candidate for any number of very-high-altitude subsonic aircraft types. Other uses include underwater vehicles for auxiliary power, extra-terrestrial vehicles (ground or atmospheric) or other medium level power applications where free oxygen is not available for aspiration and/or combustion.

***

044 ARC
92-1-03.09-1127 NAS02-13780
A Flexible Integrated Visual Display for Flight Management
Technology International, Inc.
429 West Airline Highway, Suite S
Laplace, LA 70068
Zeinab Sabri (504-652-1127)

Advanced image storage and presentation, as well as information flow control and selection, will be developed to improve aircraft flight systems management and to reduce pilot error and workload. Two control and information management concepts will be used. The first is the Ziebolz controller which uses simulation to generate a predicted display based on present conditions and actions. This display can be used effectively with radar imaging displays by presenting time-compressed information, thereby providing a clearer display of positions and movements of other aircraft or other visual targets. The second is the development of an "intervening black box," or computer managed information system to regulate pilot workload by storing information and presenting a rate-controlled, prioritized information input. This system allows the pilot to select needed information and control its presentation rate using menu driven displays. The need and justification for both of these concepts have been well documented in aviation literature. Modern computer technology has made their realization possible.

Potential Commercial Applications: Devices employing the Ziebolz controller concept in presenting predictive radar images, hardware capable of producing computer-managed pilot workload, and improved information displays for aircraft have wide commercial applications.

***

045 LaRC
92-1-03.09-1457 NAS01-19898
A Prototype Flight-Management-System Error Monitor
Search Technology, Inc.
4725 Peachtree Corners Circle, Suite 200
Norcross, GA 30092
Ronald L. Small (404-441-1457)

An error monitor (EM) to help pilots reduce or eliminate the consequences of flight management system (FMS) errors will be developed. This FMS error monitor is based on a human-centered approach to the problem of pilot FMS programming errors. Rather than attempt to redesign the FMS to completely eliminate errors (an impossible task), a human-centered approach focuses on reducing or eliminating the consequences of errors. A prototype FMS error monitor will be developed to demonstrate the feasibility of this new approach to pilot error. Error monitoring will be used to prevent the consequences of realistic FMS programming errors by alerting the pilot (or observer). This initial prototype EM only considers a small subset of pilot errors, but proves the feasibility of the approach for future, more fully developed systems. NASA and the commercial aircraft industry will benefit by having an extensible error monitor design which can indicate all types of pilot errors. This project will also develop a demonstrable prototype that can be modified for full-mission, piloted simulation evaluations in Phase II. Phase III will evaluate the EM in flight test.

Potential Commercial Applications: A family of human-system error monitors could be applied in aviation and other industries (space, nuclear power, etc.) to prevent catastrophes and improve operational efficiencies.

***

046 ARC
92-1-03.11-9457 NAS02-13688
An Unsteady Aerodynamics Model Based on Indicial Theory for Multidisciplinary Flight Simulations
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Daniel J. Lesieutre (415-968-4653)

Multidisciplinary simulation of aerospace vehicles requires knowledge/input of the unsteady aerodynamic characteristics of the rigid, aeroelastic, and aeroservoelastic vehicle modes. Indicial theory has been successfully applied to model unsteady aerodynamics using potential flow solvers offline to obtain indicial responses (functions) for step inputs in boundary conditions. However, when indicial theory is used with a Navier-Stokes flow solver, the effects of viscosity and turbu-

lence preclude calculating indicial functions to step inputs in boundary conditions. This project will seek to obtain accurate indicial functions with an offline Navier-Stokes flow solver. Phase I will demonstrate in two dimensions, the feasibility of generating accurate indicial functions in the Laplace and/or time domain with off-line Navier-Stokes calculations. The method will be tested for a case involving a two-dimensional airfoil in pitch and/or plunge by comparing phases and amplitudes of unsteady aerodynamic loads using the indicial functions with results from direct numerical simulations using the Navier-Stokes solver. The innovation will provide a more efficient and more accurate integrated design of structures, aerodynamic, and control systems for advanced aerospace vehicles.

Potential Commercial Applications: The two-dimensional approach demonstrated in Phase I will be extended to three dimensions in Phase II. The computer program deliverable after Phase II will be made into an unsteady aerodynamics shell containing the indicial theory approach including pre- and post-processors applicable to any time-accurate Navier-Stokes solver. This shell can then be incorporated into simulation systems for use in the design of various aspects of advanced aerospace vehicles.

***

04: Materials and Structures

047 LeRC
92-1-04.01-7143 NAS03-26850
High-Temperature, Oxidation-Resistant Fiber Coating for Toughened Ceramic-Matrix Composites
Hyper-Therm, Inc.
735 Alabama Street
Huntington Beach, CA 92648
Wayne S. Steffier (714-960-7143)

Ceramic-matrix composites (CMCs) are actively being developed for a variety of high-temperature military, aerospace, and industrial applications. While possessing high specific strength and stiffness, high fracture toughness, and exceptional oxidation resistance at elevated temperatures, the utility of current CMCs are severely limited by their susceptibility to oxidation-embrittlement and strength-degradation when stressed at or beyond the matrix cracking stress point and subsequently exposed to high-temperature oxygen. CMCs are classified by the low linear-elastic strain-to-failure of the matrix constituent relative to the reinforcing fiber. For the current state of technology, the linear-elastic region represents the "useful" design stress-strain region due to the harmful effects of environmental degradation of the compliant fiber coating (i.e., carbon, boron nitride) at elevated temperatures following matrix cracking. The objective of Phase I is to develop and evaluate an advanced, oxidation-resistant fiber coating technology for advanced CMCs consisting of an engineered porous silicon carbide (SiC) produced by chemical vapor infiltration (CVI). Two-dimensional laminated SiC/SiC plates will be fabricated incorporating a compliant, relatively weak and brittle fiber-matrix interface region which has been physically tailored by using controlled porosity to impart the necessary mechanical characteristics which will enhance the composite's strength and toughness. Several fiber coating porosity levels will be developed in CVI, SiC-densified composites and evaluated in high-temperatures stressed oxidation environments.

Potential Commercial Applications: Ceramic-matrix composites are important materials for a variety of thermostructural applications in aerospace propulsion combustors and nozzles, hypersonic airframe thermal protection systems, spacecraft re-entry heatshields, land-based turbine and power generation components, radiant burner and heat exchanger tubes, and other industrial applications.

***

048 LeRC
92-1-04.01-9471 NAS03-26840
Multifunctional Interface Coatings for Sapphire Monofilaments
MSNW, Inc.
P.O. Box 865
San Marcos, CA 92079
George H. Reynolds (619-489-9471)

Phase I will examine multifunctional coating concepts for sapphire monofilaments to be used in the fabrication of sapphire-superalloy composites by the wire arc-spray process. Coupled thermochemical-thermomechanical analyses will be used to select coating compositions and configurations. The effects of emplaced coatings on filament mechanical properties will be determined. Specimens of coated monofilaments will be supplied to NASA's Lewis Research Center for independent evaluation and composite fabrication trials.

Potential Commercial Applications: The coating concepts are regarded as an enabling technology for use of sapphire-superalloy composites, particularly as fabricated by the wire arc-spray process, for the nozzle substructure of the high-speed civil transport.

***

049 LeRC
92-1-04.02-4626 NAS03-26843
Edge-Defined Film Growth or Stepanov Processing of High-Temperature Fibers for Composites
Advanced Crystal Products Corporation
Conn Street at Fowle
Woburn, MA 01801
Winfield B. Perry (617-933-4626)

Progress in ceramic and intermetallic high-temperature composites is limited by the currently

available ceramic fibers. Single-crystal oxide fibers have superior microstructure, high melting points, high strength and modulus, low creep at high temperature, and resistance to oxidation. Recently, there has been considerable interest in mullite ($3Al_2O_3$-$2SiO_2$) as an enabling propulsion material because it has good high-temperature strength and resistance to creep properties. Although it is a single-crystal, continuous mullite fiber is very difficult to grow due to incongruent melting and a range of solid solution. An innovative approach, using edge-defined film growth or Stepanov growth methods, should be feasible for processing single crystal mullite fiber. These technologies will be investigated and developed to produce initial quantities of fiber for NASA.

Potential Commercial Applications: Applications include reinforcement of intermetallic and ceramic matrix composites used for advanced turbine engine hardware, e.g., high speed civil transport.

***

050 LeRC
92-1-04.02-6636 NAS03-26849
An Innovative Process for Fully Dense, High-Performance, Ceramic-Matrix Composites
Triton Systems, Inc.
186 Cedar Hill Street
Marlborough, MA 01752
R. Ross Haghighat (508-460-9493)

Phase I will demonstrate a simple, reproducible, cost-effective, and near net-shape approach for transfer molding of advanced fiber-reinforced, ceramic-matrix composites using an entirely new process. The project will expand this technology to understand more fully its processing parameters and to optimize this technique for the mechanical, physical, and thermal performance of the final composite. The result will be complex-shaped, fiber-reinforced, ceramic-matrix composites (CMCs) which are designed to outperform CMCs processed by different methods. This approach is based on resin transfer molding of organic matrix composites which has been in use for several decades as a lower-cost alternative to autoclave curing and other labor and capital intensive processes used in high-performance applications. The advantages of this process are 1) its ability to deliver near-net-shape complex shapes in high volume and at low cost with good surface topography, 2) flexibility in tooling and materials, 3) easy part consolidation through molded-in parts and fittings, 4) fast production cycles, and 5) less than 2 percent voids. Phase I will optimize the process conditions, fabricate, and characterize several fiber reinforced CMC specimens using ceramic transfer molding technique. Phase II will optimize the process for maximum strength, toughness and high temperature performance.

Potential Commercial Applications: The process will provide a rapid, cost-effective means of producing high performance complex geometry CMCs for a variety of host applications, including radomes, active and passive components in ceramic engines, rotor blades, exhaust ducts, turbo props, gun barrels, and advanced armor.

***

051 LeRC
92-1-04.03-0018 NAS03-26839
Portable, Parallel, Stochastic Optimization for the Design of Aeropropulsion Components
Applied Research Association
4300 San Mateo Boulevard, NE, Suite A220
Albuquerque, NM 87110
Robert H. Sues (505-881-8074)

This project will develop a parallel, stochastic optimization (PSO) methodology that is portable across a wide range of parallel computers. The method will deterministically treat the optimization objective function, while the optimization constraints will be probabilistic and multidisciplinary. In this approach the stochastic optimization problem is inherently parallel at several levels. This parallelism will be fully investigated. Since the methodology is readily applicable to the design and optimization of aeropropulsion components, Phase I will seek to optimize the aerodynamic performance of an advanced propfan blade subject to aeroelastic constraints. This work will determine the feasibility of developing a larger scale, general-purpose PSO methodology which treats simultaneous, multidisciplinary optimization.

Potential Commercial Applications: This research will identify the optimal approach to solving global design problems using parallel stochastic optimization and provide groundwork for the development of commercial analysis and design tools.

***

052 LeRC
92-1-04.03-0700 NAS03-26842
Massively Parallel Computational Methods Augmented with Neural Net Technology for Structural Analysis and Design
MRJ, Inc.
10455 White Granite Drive, Suite 101
Oakton, VA 22124
Rong C. Shieh (703-385-0700)

The goal of this project is to develop innovative numerical algorithms and superefficient computational capabilities in a massively parallel processing (MPP) environment for finite element, method-based structural analysis and reanalysis, applying neural net technology and structural design optimization. Phase I will formulate numerical algorithms, and, after a screening process, a selected subset of algorithms will be implemented on the MPP environment of a CM (CM-2, CM-200 or CM-5) computer for numerical testing and demonstration of the super-efficiency of the algorithms. Phase II will develop and implement of the most promising set(s) of algorithms, as well as develop a prototype CM computer

code. The new capabilities will not only solve some demanding computation structural analysis and optimization problems, but will also allow costly experiments to be replaced with numerical simulations. Furthermore, these advances will provide opportunities to accelerate computational time-intense simulations, achieve multivariable optimization, and solve otherwise unsolvable problems in conventional serial or even vector supercomputers.

Potential Commercial Applications: The end products, i.e., the MPP structural analysis and design technology and an associated general purpose CM computer code or code system, will be of interest to various industries in providing useful structural design and analysis tools in support of both structures research and design activities.

***

053 LeRC
92-1-04.04-6627 NAS03-26846
Probabilistic Process Modeling for the Consolidation of Titanium-Based, Metal-Matrix Composites
Alpha Star Corporation
1544 6th Street, Suite 102
Santa Monica, CA 90401
Roy H. Lorenz (310-458-6627)

A computational model will be developed that provides a continuous simulation of the consolidation processes and resulting microstructural evolution associated with the powder-metallurgy-based manufacture of continuously reinforced titanium matrix composites. The model will couple the computational methods of probabilistic simulation, distinct-element analysis, and mechanism-based deformation mechanics. The use of probabilistic simulation will provide the stochastic information necessary to initialize and construct a discrete unit cell representative of the uncertainties in both the geometry (i.e., variation of powder mesh size and interfiber spacing) and constituent material properties. The resulting unit cell is then implemented to conduct a distinct-element analysis to simulate the evolution and refinement in networking contacts and contact stresses as temperature and pressure are applied as a function of time to the boundary elements of the cell. As the individual contact stresses evolve, the resulting ensemble of particle deformations are calculated incrementally using mechanism-based equations. By iteratively calculating the changes in contact areas, neck growth and void closure, each stage of the consolidation process can be discretely simulated until the theoretical full density is achieved. The development of this capability will provide a new tool to aid in metallurgical evaluation and materials processing parameterization to better meet the demands of new aerospace propulsion systems.

Potential Commercial Applications: The model can be integrated into intelligent materials processing control systems to optimize production cost, end material quality and final component producibility for use in advanced aeropropulsion systems. It can also be used to aid in the research and development of new material systems, manufacturing procedures, and processing parameter selection.

***

054 LeRC
92-1-04.04-8145 NAS03-26848
Computational Fluid Dynamics Tools for Parametric Studies in Materials Processing
Daat Research Corporation
17 Montview Drive
Lyme, NH 03768
Arkady S. Dvinsky (603-643-8145)

A library of computational fluid dynamics (CFD) codes specifically tailored and optimized for selected materials science applications will be developed. The codes will utilize novel numerical techniques to achieve high performance. Phase I will demonstrate the capabilities of the CFD techniques on a sample system. Based on the results of the numerical experiments, the firm will develop specifications of the computer programs to be delivered to NASA in Phase II. Furthermore, we will develop a plan for the verification, documentation, and delivery of the developed programs to NASA in Phase II.

Potential Commercial Applications: A predictive tool that can quickly and accurately model advanced materials processes would be very useful to the electronics and aeropropulsion industries. With the aid of such predictive tools, trial-and-error development of new materials will be significantly improved, resulting in savings of time and money.

***

055 LaRC
92-1-04.06-4015 NAS01-19901
Spray Droplet and Grain Size Determination by AC-Susceptibility to Facilitate Adaptive Process Control
Quantum Magnetics, Inc.
11578 Sorrento Valley Road, Suite 30
San Diego, CA 92121
A. R. Perry (619-481-4015)

This project addresses the need for an electromagnetic sensor for measuring the droplet size and spray density of metals and other conductors. A significant improvement in the quality and reliability of metal matrix composites can be achieved by using this sensor within the deposition process. The sensor measures distribution of droplet sizes that are present in the deposition spray by using a variable frequency ac-susceptibility technique to provide real-time information about the metal spray without affecting it. A process controller,

therefore, will be able to maintain the spray parameters within tight bounds.

Potential Commercial Applications: The results of this research will be an inexpensive supplement to conventional spray-droplet technology, particularly in improved quality in spray deposition manufacturing processes.

***

056 LaRC
92-1-04.07-1100A NAS01-19870
Molecular-Level Matrix Inhibitions in Carbon-Carbon Composites
Advanced Technology Materials, Inc.
7 Commerce Drive
Danbury, CT 06810
Philip Chen (203-794-1100)

Improving the stability of carbon-carbon composites in oxidatively aggressive environments is key to expansion of this material system's utility. Protective coatings, combined with the incorporation of boron particles within the matrix, provide improved oxidation protection but are inadequate for applications in high temperature engine components. While the boron particles react with oxygen to effectively seal cracks in the coatings, the overall effect on the matrix is not optimal. Boron particles congregate in fiber-rich areas resulting in inadequate protection of matrix-rich areas and inhomogeneity in composite strength. The required high boron levels (~40 percent by weight) impart moisture susceptibility to the composite. Molecular dispersion of carborane through the matrix can give comparable oxidation inhibition at only 10 percent by weight. Additionally, composite uniformity and moisture resistance will be enhanced. Phase I will incorporate carborane and the use of calcium organometallic chemistry for reduced moisture pick-up. Microanalytical techniques will be used to map the boron and calcium distribution in these samples for comparison to particulate derived samples. Phase II will translate the results of Phase I into the manufacture of composites for cyclic oxidation studies. Prototype structural composite components will be fabricated and provided to NASA.

Potential Commercial Applications: Carbon-carbon composites are strong, tough, lightweight, highly refractory materials with unparalleled strength retention and creep resistance at very high temperatures. This project is expected to identify a practical means of improving the oxidation resistance of these materials for structural applications.

***

057 LaRC
92-1-04.07-1980 NAS01-19920
Innovative Oxidation Protection Systems for Carbon-Carbon Composites
Materials & Electrochemical Research
7960 South Kolb Road
Tucson, AZ 85706
R.O. Loutfy (602-574-1980)

This project addresses the need for adequate oxidation protection systems for carbon-carbon (C-C) composites that enable operation for more than 1000 hours at temperatures up to 1650°C for the aerospace and turbine engine industries. Superior oxidation resistance C-C composites may be achieved through production of Si and Si_3N_4 surface layers. Current processing techniques result in thermal expansion mismatch difficulties which cause microcracking and the subsequent oxidation of the C-C composite. This problem is generally viewed as the limiting factor in the use of C-C composites for high temperature, structural applications in an oxidizing environment. The project's approach involves the use of an innovative processing technique that will minimize thermal expansion mismatch difficulties by optimizing the surface layers while retaining the excellent properties of the C-C composites. Samples will be fully characterized in terms of microstructural characteristics, mechanical properties, and oxidation resistance by both isothermal and cycling tests.

Potential Commercial Applications: Potential applications include components for airframe applications (e.g., nose caps, thermal protection systems), friction applications (e.g., aircraft brake discs), propulsion applications (e.g., rocket nozzle throats) and military applications (e.g., nose tips). Other potential applications include medical prostheses, chemical heat exchangers, and turbine engine rotors.

***

058 LaRC
92-1-04.08-1510 NAS01-19882
Augmented Penetrating Capability for Reverse Geometry X-Ray® System
Digiray Corporation
2239 Omega Road
San Ramon, CA 94583
Richard D. Albert (510-838-1510)

The company currently produces a Reverse Geometry X-Ray® System that is used in various non-destructive evaluation applications. In order to image aluminum and composites thicker than five centimeters, additional non-destructive probing energy is necessary. This project will perform the necessary research and development to determine the factors limiting the operative kilovoltage of the present 100 kV system, implement changes to achieve 125-135 kV, and evaluate the requirements for obtaining 160 kV and beyond. The high voltage level of the present system will be increased by

small increments until nonreliable operation occurs. Evaluation of failure(s) in reliability will orient the development program to augment system potential. A new power supply will be procured for operation at higher kV levels. Components for system focus, feedback, tube performance, and system stability will be redesigned and assembled. The improved imaging capability of the system will be evaluated with NASA specimens and other aerospace coupons. If Phase I is successful, Phase II will explore obtaining a 160 kV level.

Potential Commercial Applications: Applications include non-destructive testing of turbine blades; aging aircraft and spacecraft; welds, braises, and castings; aerospace materials; automotive aluminum engine casings; air bag units; electronics (surface mount solder joints, ceramic circuit boards, advanced and hybrid packages); and fuses.

***

059 LaRC
92-1-04.08-3088 NAS01-19895
Embeddable Distributed Moisture Sensor for Nondestructive Inspection of Aircraft Lap Joints
Physical Optics Corporation
20600 Grammercy Place, Suite 103
Torrance, CA 90501
Robert A. Lieberman (310-320-3088)

This project will demonstrate the feasibility of a novel, intrinsic fiber-optic sensor whose entire length would be sensitive to the presence of moisture. This small, lightweight, inexpensive sensor could be retrofit into existing aircraft lap joints, or included in the construction of new aircraft, to warn of moisture-induced corrosion in these critical joints. Because of the sensor's unique properties, each joint, no matter how long, would require only a single sensor. Used in such "smart lap joints," the sensors would improve aircraft safety and minimize unnecessary inspections and rebuilding of lap joints in aging aircraft by detecting the presence of water well before material loss occurred. To demonstrate the feasibility of this concept, a custom optical fiber will be created whose entire cladding will be sensitive to water. The water response of this unique sensor fiber will then be completely characterized by connecting it to a simple optoelectronic source-detector pair and by exposing various sections of the sensor fiber to liquid water. The end results of Phase I will be a working "breadboard" water penetration sensor several meters long, together with a complete set of moisture response data.

Potential Commercial Applications: Makers and users of aircraft with long lap joints (like the Boeing 767) would be prime customers for embeddable moisture sensors. Other commercial applications could include: verification of water-tightness in nautical and food-processing applications, "average humidity" measurements, and in-situ integrated soil moisture determinations for irrigation control.

***

060 LaRC
92-1-04.08-4691 NAS01-19993
Advanced Microwave Imaging Techniques for Materials Processing and Monitoring
Gemtech Microwaves, Inc.
1318 Chandler Court
Acworth, GA 30102
Barry J. Cown (404-425-4691)

This project will investigate the feasibility of adapting novel microwave imaging hardware and software to permit quasi-real time monitoring and control of micro- or millimeter, wave-penetrable aerospace and commercial materials during their design, development, processing, and operational use. The innovation adapts modulated scattering arrays as multi-point sensors to provide rapid Nyquist-sampled mappings of the material's local reflection and transmission coefficients. These measured data are then used in advanced microwave imaging algorithms based on diffraction tomography (DT) and the electric field integral equation (EFIE) to image equivalent currents, complex permittivity and field distributions. Resolutions of $(1/2)\lambda$ and $(1/10)\lambda$ in the material are achieved for DT and EFIE imaging, respectively. These microwave imaging techniques directly determine electromagnetic performance. They can also be used to detect and identify many types of material structural defects.

Potential Commercial Applications: Potential commercial applications include imaging of knots and other defects in wood; delaminations in paper products; aircraft, boat, and vehicle composites; control of microwave drying processes; detection of concrete reinforcing bars; detection of drugs and weapons caches; and monitoring of deep hyperthermia treatments.

***

061 LaRC
92-1-04.09-3535 NAS01-19886
Porous Refractory Carbides Made of Discontinuous Fibers for Beamed-Energy Propulsion Systems
Micro Composite Materials Corporation
P.O. Box 12744
Research Triangle Park, NC 27709
Steve R. Wright (919-361-3535)

One critical component for a solar-thermal propulsion concept consists of porous hafnium carbide (HfC) or tantalum carbide (TaC) discs, through which hydrogen flows at temperatures exceeding 3700 K (6700 R). Discs made by conventional means using HfC or TaC powders cannot withstand the high thermal and mechanical stresses. This project will manufacture absorber discs by sintering preforms made of pure HfC and TaC discontinuous fibers. A proprietary process that

is used by the firm to produce TiC fiber can also generate fibrous forms of other refractory carbides such as TaC and HfC. Absorber discs made of these fibers would be very durable and, by varying the composition of the preforms (i.e., fiber aspect ratio, packing, etc.), would have uniform, controlled porosities. Phase I will demonstrate that HfC and TaC fibers can be created, that porosity can be controlled in discs made from these discontinuous fibers, and that this manufacturing process can produce durable, full-scale absorber discs. Sample quantities of HfC and TaC will be delivered to NASA. Parameters that affect porosity will be determined by making and analyzing a series of porous TiC fiber plugs. Finally, a full-scale porous TiC fiber disc will be fabricated for delivery to NASA. Phase II will fabricate full-scale set(s) of porous HfC and TaC absorber discs for bench testing by NASA.

Potential Commercial Applications: The fibrous carbides could be used in nuclear power in laser, chemical and industrial high-temperature thermal applications; in ceramic composites to increase fracture toughness; in metal matrices as a strengthening stiffening filler; and, in powdered ceramic binders, producing a strong, tough, lightweight, reusable, extremely high-temperature refractory, having excellent thermal properties for protection of aerospace vehicles or hypersonic wind tunnel components.

***

062 LeRC
92-1-04.10-3812 NAS03-26847
Novel Additives for Perfluoropolyether Lubricants
Exfluor Research Corporation
8868 Research Boulevard, #206
Austin, TX 78758
Thomas R. Bierschenk (512-454-3812)

The objective of this project is to synthesize additives to enhance the properties of perfluoropolyether fluids. The lack of suitable additives that are soluble in perfluoropolyether fluids is preventing their use in high-temperature applications. The additives will be characterized and assessed in a series of tests that have been developed primarily by the U.S. Air Force for the evaluation of formulated perfluoropolyether fluids. The goal of this project is to develop an additive that will function as either an oxidation inhibitor or a boundary lubricant for perfluoropolyether fluids.

Potential Commercial Applications: The new additive will extend the useful temperature range of the fluids, thus making them especially compatible for many new high-temperature applications. The formulated fluids will find uses both as lubricants and as vibration-dampening recoil fluids in space applications where extreme environments exist.

063 MSFC
92-1-04.10-5940 NAS08-39800
Atomic-Oxygen Resistant Tribo-Surfaces
Colorado Engineering Research Laboratory, Inc.
1500 Teakwood Court
Fort Collins, CO 80525
Ronghua Wei (303-484-5940)

This project will evaluate the tribological performance of commercially available solid and grease lubricants in a simulated atomic oxygen (SAO) environment and will investigate innovative lubrication concepts with long-duration tribological resistance to atomic oxygen (AO). Spacecraft mechanisms operating in the low earth orbit environment will be subjected to long duration (up to 30 years) exposure to AO, which can degrade the tribological performance of epoxy-bonded, solid lubricants and organic-based greases. This degradation can jeopardize mission success. This project will perform tribological screening in SAO and subsequently rank commercially available lubricants of interest to NASA for space mechanism applications. This project will also investigate and develop two novel solid lubricant materials: a more adherent, SAO-resistant, diamond-like carbon coating with an improved, intermediate-bond-layer material and a longer endurance molybdenum disulfide coating produced by ion implantation of the substrate. Benefits to NASA from Phase I will include quantitative ranking of the synergistic SAO-wear resistance of commercial lubricants and the development of two new solid lubricants of potential application for space mechanisms that may be subjected to long-duration, SAO exposures.

Potential Commercial Applications: This project will provide a quantifiable screening test method to evaluate lubricant and tribomaterials' resistances to sliding wear under a simulated atomic oxygen environment and will provide increased-lifetime, low-friction, and low-wear solid lubricants (i.e., diamond-like carbon and molybdenum disulphide) for components such as bearings, gears, shafts, cams, ways, and hinges for terrestrial and space systems.

***

064 LaRC
92-1-04.11-6636 NAS01-19909
Processing of High-Performance Poly(Arylene Ether Benzimidazole)
Triton Systems, Inc.
186 Cedar Hill Street
Marlborough, MA 01752
R. Ross Haghighat (508-460-9493)

This project will conduct a comprehensive study of the properties, identify applications, and establish markets of a new, ultrahigh-performance polymer, poly(arylene ether benzimidazole) (PAEBIs), developed by NASA. These thermally stable polymers exhibit outstanding properties, including high glass transition temperatures (Tg) (350°C); high compressive, tensile

and flexural strengths; excellent adhesion to metals; tailorable coefficient of thermal expansion (CTE); and a low dielectric constant. These properties can be further enhanced for specific applications. The project will seek ways to maximize the properties of the PAEBI polymer, including its tensile, compressive, and flexural strengths, dielectric properties, and adhesive characteristics. The will test the crystalline response of the polymer to annealing and orientation, and will identify potential applications based on the property optimizations achieved.

Potential Commercial Applications: PAEBI, because of its impressive combination of properties, is a candidate for a variety of applications, including leading edges of the aircraft, electric, and electronic markets for insulators and next generation connectors, switches, and electronic components. With its tailorable CTE, potentially low friction, and good mechanical properties, PAEBI may find a home in many general industrial uses such as gaskets, O-rings, and bearings.

***

065 LaRC
92-1-04.11-9101 NAS01-19885
Synthesis of Reactive Toughening Polymers Based on NASA Langley Research Center Thermoplastic Polyimides

Imitec, Inc.
1990 Maxon Road, P.O. Box 1412
Schenectady, NY 12301
Betty Tung (518-374-9101)

Improvements in toughness are always desirable in polymeric systems, especially in polyimides which are often inherently brittle. The conventional "rubbery" tougheners with sub-ambient glass transitions are not usually suitable for polyimides due to the required, high processing, and use temperatures. This project will synthesize several thermally stable tougheners based on NASA Langley Research Center thermoplastic polyimides containing reactive end groups. Depending on the miscibility between the matrix polymer and the toughening agent and the compositions of each component, the new system may either possess homogeneous, microphase-separated, phase-separated, or network morphology. The morphology will determine the toughening mechanism as well as the degree of toughening. The major advantages of these tougheners should include ease in processing as well as thermal stability.

Potential Commercial Applications: The thermally stable reactive tougheners based on LaRC thermoplastic polyimides may find application for high temperature composites, molding resins, adhesives, laminating and film products.

***

066 LaRC
92-1-04.12-5058 NAS01-19876
Innovative, Low-Cost Composite Fabrication Using E-Beam Cured Pregreg Processable Siloxane

Aspen Systems, Inc.
184 Cedar Hill Street
Marlborough, MA 01752
Thomas C. Walton (508-481-5058)

This project addresses the feasibility of a new, low-cost composite fabrication technology that utilizes a rapid-cure electron-beam. The technology will develop suitable composite precursors such as pre-impregnated forms of reinforcements (e.g. unidirectional or woven graphite or fiberglass). Currently available electron-beam curable resin systems exhibit very low viscosity (e.g. ≈ 50 - 100 cps). Although these viscosities are suitable for such composite manufacturing techniques as filament winding, pultrusion, and resin transfer molding, they are currently unsuitable for pre-pregging. Increasing the viscosity of the resins during pre-preg formation is key need in composite fabrication. The company has demonstrated that facile electron-beam and UV-induced polymerization of novel silicon-containing epoxy (SCE) monomer resins can be carried out. Further, it has been shown that these resins, when cured, exhibit a high degree of resistance to oxygen plasma, perhaps the highest resistance yet found. The objective of this project is to exploit the unique oxygen plasma resistance of these resins in composite applications specifically targeted to space application. However, the epoxy-silicone monomers are free-flowing, low viscosity liquids and cannot be directly used in composites fabrication.

Potential Commercial Applications: This concept will provide a cost-effective means of fabricating high quality, thermal stress-free composites which will have applications in the aerospace and automotive industries and the civil engineering field.

***

067 LaRC
92-1-04.13-0001 NAS01-19900
High-Power-Density Piezoelectric Actuator for Noise and Vibration Reduction

PCB Piezotronics, Inc.
3425 Walden Avenue
Depew, NY 14043-2495
Richard W. Lally (716-684-0001)

The application of piezoelectric materials to the control of noise and vibration makes possible the development of high-power-density actuators. The further development of piezo-materials, power schemes, and a control strategy may be necessary to improve the utility of piezoelectric actuators for noise cancellation and vibration control.

Potential Commercial Applications: Automotive, aerospace and industrial machines can benefit from applica-

tion of this technology through reduced cost, weight, noise, and vibration while improving accuracy, safety, and quality.

***

068 LaRC
92-1-04.13-9647 NAS01-19871
Continuous Feedback Smart Composites
Ceranova Corporation
P.O. Box 278
Hopkinton, MA 01748-0278
Mark V. Parish (508-435-9647)

The success of advanced commercial and military aerospace transport apparatus depends on the development of sophisticated smart materials and structures. This project will develop a process to fabricate an innovative shape memory allow (SMA)-ceramic piezoelectric array device that can actively sense and actuate a composite system at discrete locations throughout the composite structure in a closed-loop-feedback manner. The innovative SMA-ceramic piezoelectric actuator-sensor array, when embedded in a composite, will enable the intelligent actuation and control of the smart composite's shape, at discrete locations, to achieve aerodynamic efficiency or suppress vibrations. In addition to shape control of the composite, our novel SMA-piezoelectric device will enable the composite's in-process, as well as in-service, non-destructive evaluation. Phase I focuses on development of the novel piezoelectric device and demonstration of shape modification of cantilever beams.

Potential Commercial Applications: Composites that sense and respond to vibration stimuli can be used in many NASA and civilian applications, such as aircraft, marinecraft, and even automotive. In addition to aero- and fluid-dynamic applications on airfoils, marine vessel skins and rotor and/or propeller blades, "smart" composites such as those described in this document will be invaluable in hydrophone applications for the U.S. Navy. These composites may also be used in motor mounts.

***

069 JPL
92-1-04.14-8044 NAS07-1211
Vapor Deposited, Metal-Matrix Composites for Dimensional Stability without Hysteresis
Cordec Corporation
P.O. Box 188
Lorton, VA 22079-0188
Raymond J. Weimer (703-550-8044)

Large, periodic thermal excursions cause significant dimensional changes in large orbiting structures. New metal-matrix composites (MMC's) with near-zero coefficients of thermal expansion (CTE) developed to address this issue were generally aluminum or magnesium alloys reinforced with pitch-based carbon fibers. However, dimensional hysteresis effects under thermal cycling limit the potential of such materials for high precision space structures. Physical vapor deposition (PVD) techniques have been developed to manufacture continuous graphite-magnesium MMC precursor tapes that were easily consolidated by hot-press diffusion bonding. These MMC's had a CTE of approximately 0.1 PPM/K and a maximum dimensional change (hysteresis) less than 10 PPM during thermal cycling from 116 K to 421 K, that is, over the entire range of temperatures anticipated for orbiting platforms. PVD methods led to the only MMC's to exhibit such stability in the as-fabricated condition (annealed) whereas powder and liquid metal processes could not. As-fabricated thermomechanical properties are crucial because large, thin-gauge MMC structures cannot be easily heat-treated. Tentative mechanisms have been identified and will be exploited and refined through a unique process capability in Phase I to demonstrate CTEs less than 0.01 PPM/K with less than 1.0 PPM hysteresis over the same temperature range. Phase II will apply this technology to production of prototype structures.

Potential Commercial Applications: These new MMCs are easily consolidated into long tubes, stiffeners, and skins, making them especially well suited for advanced antennas for which tradeoff studies predict a six decibel performance gain. They are also attractive for optical benches and telescope parts.

***

070 JPL
92-1-04.15-2407 NAS07-1214
Terfenol-D Active-Truss Strut
Intelligent Automation, Inc.
1370 Piccard Drive, Suite 210
Rockville, MD 20850
Leonard Haynes (301-990-2407)

This project will develop the conceptual design of a new Terfenol-D active-truss strut to be used for large, high-precision structural systems. The actuator used in the strut exploits the magnetostrictive material Terfenol-D, which expands and contracts under the influence of a magnetic field, as the active element of the strut. The actuator combines the features of a Terfenol-D inchworm mechanism for coarse control with a Terfenol-D linear actuator. The coarse adjustment of the actuator would be limited only by the length of the outer housing and the number and spacing of the coils, and the vernier adjustment capability would be approximately ±100 microns. The strut will remain in its static position in a power-off situation with no degradation in its force resisting capability. The actuator would have two main features. First, it could easily generate, plus-or-minus several thousand newtons of active control force over a frequency range orders of magnitude greater than 0 Hz to 100 Hz. Second, it has no moving parts in the conventional sense; therefore, its reliability should be excellent. The actuator can be fabricated with a hole through its center to allow interferometric measurements to be made through the strut. A reference shaft could

also be passed through its center for connection to a differential eddy current proximity sensor in a manner similar to what was done by the Jet Propulsion Laboratory (JPL). The resolution of the displacement measurement using the JPL design is better than 1 nm.

Potential Commercial Applications: The active strut will be directly usable by NASA for application in large space structures and by the Department of Defense for space-based weapon and sensor systems. Beyond vibration isolation, the strut would be an ideal linear actuator for any high reliability, high performance application.

***

071 LeRC
92-1-04.17-8295 NAS03-26844
High-Reliability, Long-Term Lubricator
The Technology Partnership
8030 Coventry
Grosse Ile, MI 48138
David Bettinger (313-675-8295)

Mechanical devices for space require long-term, in-service lubrication tailored to initial and continued mechanical movement. Space bearing points are usually inaccessible so that relubrication must be provided within the system as launched. Certain shrink plastics can provide a reliable, lightweight lubricator where periodic lubrication is either untimely, inaccessible, or hazardous. Prototype heat shrink dispensers have proven to be capable of temperature-responsive, automatic lubricant supply. Shrink plastics may be formulated to be self-activated by aging or ultraviolet radiation, thereby creating many space uses. Replacing pumped and solenoid dispensers with shrink tubes will also reduce lift-off weight. Furthermore, shrink tubes allow lubricant purging and additive replenishment without outgassing. Phase I will survey current and potential lubricator applications on NASA space equipment and survey available shrink plastic materials. The application of the materials will then be ranked. Phase II will develop and test candidate lubricators.

Potential Commercial Applications: Lubrication intervals for automotive and other specialty commercial applications can be extended using this lubricator; 200 million units a year in many configurations could be required.

***

072 LeRC
92-1-04.17-9676 NAS03-26834
A Low-Cost, Compact, Non-Explosive Pin Puller for Aerospace Applications
Tini Alloy Company
1621 Neptune Drive
San Leandro, CA 94577
John D. Busch (510-483-9676)

A shape-memory-alloy-actuated pin-puller that is inexpensive, compact, reusable, and non-outgassing will be developed. Such a device is expected to simplify and significantly lower the cost of satellite deployment mechanisms by reducing overall spacecraft weight, minimizing hazards to assembly personnel, and eliminating the need for protection against gaseous discharge of pyrochemicals or paraffin. The primary objective in Phase I is to demonstrate the technical feasibility of a shape-memory-alloy-actuated pin puller by investigating and evaluating two different approaches in parallel. Initial experiments will identify the advantages and disadvantages of each design. Test results and a deliverable prototype of each version will be submitted to NASA for critique and selection.

Potential Commercial Applications: The pin-puller will be immediately beneficial to the satellite industry for solar array and antenna deployment and for similar remote release applications. Additional applications include oceanographic vehicles and instrumentation, buoy deployment, and aircraft systems.

***

073 GSFC
92-1-04.18-5058 NAS05-32411
Highly Adherent, Conductive, and Economical Plasma-Thermal-Sprayed Siloxane-Elastomer Thermal Control Paints
Aspen Systems, Inc.
184 Cedar Hill Street
Marlborough, MA 01752
Thomas C. Walton (508-481-5058)

Current thermal control spacecraft coatings are very sensitive to handling, involve coatings that contain volatile organic compounds, and are extremely expensive. This projects goal is the development of an economical painting technology to make obsolete many organic solvent and waterborne coatings. This new coating process does not discharge toxic or polluting organic solvents into the atmosphere, and the hypervelocity plasma-spray conditions provide thermally for extremely high rates of heat transfer, allowing polymer flow conditions which give very high adhesion to substrates, eliminating the need for a primer. The technology involves a newly designed plasma-thermal-spray painting process which can accommodate a wide variety of atomic oxygen-resistant polymeric and inorganic binders, some never before considered. These binders include the following: tough, elastomeric, off-gassing and contaminant, and commercially available siloxane-PEI copolymers with electrically conductive pigments. The polymers are based on a proven technique whereby molten metals and ceramics are sprayed and yet the substrate or coating is not harmed.

Potential Commercial Applications: Applications may include coatings in the chemical process industry and for bridge, ship, and tanker coatings, auto body

coatings, railcar coatings, and other industrial finish coatings.

***

074 GSFC
92-1-04.18-6714 NAS05-32422
Elastomeric Polyimides
Fluorochem, Inc.
680 South Ayon Avenue
Azusa, CA 91702
Kurt Baum (818-334-6714)

O-ring and gasket materials for space applications must meet ordinary requirements for strength and resiliency, but must also withstand radiation and low temperatures in space, atomic oxygen in low earth orbit, and high temperatures on launch. Polyimides, which are widely used for space structural applications because of their ability to withstand severe conditions, are generally rigid materials that do not provide the resiliency needed for o-rings and gaskets. Fluorine-containing segments in polyimides are known to reduce glass transition temperatures (Tg) without impairing the stability properties. Under this project, polyimides with novel, fluorinated segments will be synthesized.

Potential Commercial Applications: The products are potentially useful for a variety of o-ring and gasket applications where chemical and thermal stability are needed in addition to low-temperature resiliency.

***

075 MSFC
92-1-04.19-7520 NAS08-39824
Fullerene-Based Thermal Control Coatings for Space Structures
Hot Enterprises
1350 Golden Circle, #302
Golden, CO 80401
Howard Dunn (303-762-7520)

This project will develop a new type of thermal-control coating material applying doped C_{60} (fullerene). The investigation will consider dopants of magnesium, yttrium, molybdenum, or aluminum applied exohedrally or endohedrally. Utilization of unique properties found in a new doped C_{60} coating process may provide exceptional thermal control on ceramic, polymeric, and metal matrix components exposed to low-temperature and high-vacuum conditions. The principal objective is a coating heat-transfer-coefficient modification by doping with specified dopants to produce new enhanced bonding, application, degradation resistance, or thermoelectric properties for space materials. Doped or undoped C_{60} coating material has not yet been tested for possible applications.

Potential Commercial Applications: The project's result may be a new thermal control coating material that will greatly enhance material performance on space environment.

***

076 MSFC
92-1-04.19-9669 NAS08-39801
Novel Material Concepts for Improved Spacecraft Debris Protection
Technology Development Association, Inc.
992 Old Eagle School Road, Suite 910
Wayne, PA 19087-1803
Richard C. Foedinger (215-687-9669)

The design and operation of spacecraft must give serious consideration to space debris and its effect on mission performance. Hypervelocity impacts by micrometeoroids or orbital space debris can cause severe damage to vital spacecraft systems and components. Phase I addresses the investigation and development of novel textile material concepts that offer lighter weight and improved spacecraft debris protection compared with the conventional dual plate aluminum shielding. Unlike other material concepts, these concepts combine the desired material properties and geometry to achieve the desired functionality. The material concepts include both a multiple layer, functionally gradient fabric and a flexible sandwich core fabric geometry. The concepts will be developed as a result of hydrocode analyses and material trade studies. A significant feature of the project is the investigation and preliminary development of a numerical analysis methodology for the design and optimization of fabric materials for debris shield applications. The project offers significant benefits for future NASA spacecraft which must be designed to operate in the micrometeoroid and orbital debris environment. Lighter weight, more flexible debris shields would provide more efficient protection for spacecraft such as the Space Station.

Potential Commercial Applications: Vital space systems and components will be protected from hypervelocity impact damage caused by orbital debris and micrometeoroids. Potential commercial applications include improved ballistic protective equipment for police bomb proof containers, and sporting equipment.

***

077 JPL
92-1-04.20-0771 NAS07-1221
Finite-Element Analysis of Inflatable Antennas
L'Garde, Inc.
15181 Woodlawn Avenue
Tustin, CA 92680-6487
Arthur L. Palisoc (714-259-0771)

Lightweight, inflatable structures have been shown to have tremendous potential as reflective devices in aerospace applications. This new class of structures, referred to as inflatable, deployable space structures, is currently under study and development for a number of

antenna applications. Inflatable structures undergo large deflections that could range up to more than 6,000 times the membrane thickness. This project addresses a finite element code capable of treating large deflections of on-axis inflatable antennas. The objective will be to extend this code to include the analysis of off-axis inflatable parabolic antennas. Because these structures consist of pressurized membranes, specialized analytical tools will be required for the characterization of their static and dynamic behavior on orbit. The code will be able to account for such variables as nonlinear material properties of the membrane, geometric nonlinearities, internal pressure, and local stiffening effects. The code will also be able to predict the responses due to arbitrary static, thermal, and dynamic loading conditions, including natural frequencies and mode shapes.

Potential Commercial Applications: The code may find applications in the analysis of deployable, inflatable space structures, for the analysis of the deformations and dynamics of airbag automotive deployment, and, in the medical field, to predict the deformations and dynamics of balloons used in balloon angioplasty and to study different kinds of embolisms.

***

078 HQ
92-1-04.22-2227 NASW-4782
Ultraviolet-Heat Cure Structural Adhesives
Horizon Technology, Inc.
9737 Gilbert Road
Ravenna, OH 44266
John Petroski (216-358-2227)

This project will prove the feasibility of developing structural adhesives for application and use in space. Use of adhesives in space is now limited by the application and cure conditions. These problems will be addressed by evaluating a heat-curable adhesive with an embedded heat conductor and/or source and an ultraviolet-light curable adhesive with an embedded optic-fiber-energy transmission source. Both systems will be designed specifically for application and end use performance in space.

Potential Commercial Applications: While this technology is critical for manufacturing and/or assembly in space, it would also increase manufacturing efficiencies on Earth. These systems would be excellent candidates for composite laminate repairs, with low-cure temperatures and rapid-cure times.

***

079 ARC
92-1-04.23-0236 NAS02-13795
Oxidation-Resistant Coating of Diboride-Composite Thermal Protection System
Ultramet
12173 Montague Street
Pacoima, CA 91331
Brian E. Williams (818-899-0236)

Current reusable thermal protection systems have a maximum operating temperature of approximately 1700°C. Increasing operation to the 2000-2500°C range would provide an increase in heat flux capability from two to five times that of the reinforced carbon/carbon (RCC) used on the space shuttle orbiter. Fiber-reinforced diboride matrix composites are an attractive alternative to RCC due to their superior performance in an oxidizing environment. Zirconium diboride (ZrB_2) matrix composites, in particular, have been selected for continued study because of their ablation performance, moderate density, and relatively low cost. Current fabrication methods for ZrB_2 composites lead to unprotected fiber bundle ends at exposed surfaces, which preferentially oxidize. A coating system that could infiltrate and seal the porosity near the composite surface and encapsulate the fiber bundle ends would be desirable. The goal of this project is to develop an oxidation-resistant coating system, designated Ultra2000, based on the hafnium carbide/silicon carbide system that has demonstrated oxidation protection for ZrB_2 composite materials to temperatures in excess of 2200°C. With a leading manufacturer of fiber-reinforced, diboride composite materials, Phase I will conduct a co-development effort aimed at incorporating the Ultra2000 coating as an integral component of a diboride composite, thermal protection system.

Potential Commercial Applications: This project applies to systems requiring reliable oxidation resistance at high temperatures (>2200°C), such as the National Aerospace Plan and the Space Exploration Initiative.

***

080 ARC
92-1-04.23-1729 NAS02-13800
Porous, High-Temperature, Zirconia-Silica-Boria Refractory Insulation
Cambridge Innovative Inorganics, Inc.
251 Albany Street
Cambridge, MA 02139-4279
Derek Mess (617-349-1729)

Future atmospheric entry vehicles will need new, reusable, lightweight thermal protection systems capable of withstanding significantly higher heat fluxes than is possible with currently available materials. A low density foam of a zirconia-silica-boria composition will be synthesized by a sol-gel route, using a known method for making hollow ceramic microspheres and cast bricks of refractory insulation material. Surface layers of such glassy oxides are formed in-situ during plasma arc-jet

testing of zirconium diboride-silicon carbon-carbon advanced refractory composites. The refractory foam is expected to have exceptionally good resistance to thermal shock and to exhibit a low recession rate at temperatures of 2400°C.

Potential Commercial Applications: The porous refractory material has commercial applications as a high-temperature furnace insulation and as an insulating material for heat engines and rockets.

***

081 ARC
92-1-04.23-9224 NAS02-13803
Structural Ceramic-Composite Insulation - Fiber Reinforced
Smart Ceramics
25R Olympia Avenue
Woburn, MA 01801
Jonghoon Han (617-938-9224)

Future atmospheric entry vehicles will require thermal protection materials that are more durable and lower in weight than materials currently available. This project will design and develop new continuous, ceramic-fiber-reinforced, ceramic-matrix composites (CFCCs) for structural and insulation purposes. These fabrication techniques will demonstrate that the processes can be applied to the manufacture of reliable, reproducible, and cost-effective ceramic composites that exhibit excellent thermal shock and temperature capabilities. Two material compositions that stem from the sol-gel and silane precursor technologies coupled with two innovative composite process techniques, will be employed to produce a variety of ceramic composite shapes. Rudimetry thermomechanical and physical properties will be measured.

Potential Commercial Applications: Promising commercial applications include engine components for automobiles and other heat engines. Other applications include bearings, heat exchangers, and burners.

***

082 MSFC
92-1-04.24-7572 NAS08-39802
Innovative Plasma Nozzle Techniques for Eliminating Overspray
Plasma Process
7802 Hilton Drive
Huntsville, AL 35802
George Philips Beason, Jr. (205-881-7572)

Overspray and undeposited powder are serious problems for vacuum and air plasma spray processes. Overspray and unmelted powder increase the cost of the process through wasted material and jeopardize the material quality of the deposits for both coatings and structures. Overspray occurs because commercially available plasma guns have poor nozzle design. Powder injected into the plasma flame cannot enter the plasma, overshoots the plasma, or, because of nozzle flow characteristics, is forced out of the center of the flame. By designing and testing new models, investigators can create plasma gun nozzles that have the desired flow characteristics to entrain and melt the powder, thereby eliminating, or severely reducing, overspray and undeposited powder. The goal of this project will be to design and produce perfectly expanded plasma-gun nozzles for optimizing plasma spray.

Potential Commercial Applications: Applications exist in many fields, including aerospace (rocket genies, jet engines), automotive (pistons, alternators, manifolds), and biomedical (medical and dental implants). The nozzle could also be used in superconductors, furnace retorts, and mills (rolling, paper). Future applications include the spray of high cost materials such as refractory metals, and precious metals.

***

083 GSFC
92-1-04.25-0655 NAS05-32407
Laser Brazing Process for Joining Refractory Materials to Dissimilar Metals
American Research Corporation of Virginia
P.O. Box 3406
Radford, VA 24143-3406
James M. Glass (703-731-0655)

Joining and bonding processes are needed that can join hot, non-metallic refractory materials to dissimilar metals for Space Station experiments in the Gas-Grain Simulation Facility. Permanent, low-resistance metal-graphite joints that can withstand high temperatures and high current loads will greatly simplify the construction and reliability of compact, high-temperature graphite furnaces. This project suggests laser brazing as a means of joining non-metallic refractory materials to metals while limiting the thermal degradation to regions adjacent to the joint. Innovative glass-ceramic materials having matched coefficients of thermal expansion will be used as braze fillers. Phase I objectives include evaluation of materials amenable to laser brazing of refractory composites, modification of a laser brazing vacuum system, selection of laser processing parameters, high-temperature characterization of joint properties and tensile strength, and optimization of a laser brazing system for engineering development in Phase II . Successful completion of the program objectives would result in a technique for producing high temperature (1000°C) ceramic-to-metal joints having good thermal-mechanical properties for use in graphite furnaces, welded reaction tubing and other high temperature applications.

Potential Commercial Applications: The anticipated benefits of the project include the development of improved methods and materials for joining graphite or ceramic materials to metal resulting in improved high-temperature performance and reliability. Commercial

applications of this technology would occur in the aerospace, transportation, energy, and automotive industries.

***

084 GSFC
92-1-04.25-3230 NAS05-32402
Thick-Film Metallization for High-Temperature Graphite Furnaces
Advanced Technology, Inc.
2110 Ringwood Avenue
San Jose, CA 95131
James Intrater (408-432-3230)

Currently, adhesive bonding, fastening, and welding are techniques for joining dissimilar materials used in a gas-grain simulation furnace. Each technique has its limitations when used repeatedly. A novel technique call "Intragene" can achieve metallurgical bonding between various dissimilar materials in these furnaces. This metallization process can also allow for bonding to occur between nonmetals such as graphite and metals such as copper. Phase I will develop reliable and stable, high-temperature (>1000°C) joints between graphite and copper. These joints are necessary to provide electrical and thermal performance capabilities for many applications, especially in the development of water-cooled, graphite glow-bar elements with high electrical conductivity contacts found in furnaces to be used in space- and ground-based applications. Using copper as the metallurgical end for resistive heating bars allows for conventional brazed, soldered, and screw-fit plumbing to the overall elements, while allowing for low resistivity electrical contact to be made and maintained for efficient heating.

Potential Commercial Applications: The primary applications for these joints are in high-temperature facilities such as furnaces. Other applications include high-temperature, water-cooled glow bars; graphite brushes attached to commutators; and heat sinks, heat pipes, and radiators used in the electronics and nuclear industries.

***

085 MSFC
92-1-04.26-6881 NAS08-39803
Matrix Resin With Particulate Reinforcement Grown In Situ for Injection Stereolithography Process
Advanced Ceramics Research, Inc.
841 East 47th Street
Tucson, AZ 85713
Kevin Stuffle (602-792-2616)

This project will develop a new composite resin system to be used with an injection assisted stereolithography process for the free body forming of composite parts. Since direct incorporation of particles into the resin would make resin viscosity too high for good nozzle injection, these particles will be formed by hydrolysis of liquid metal alkoxides. The alkoxides will be added to the liquid resin and will act to reduce the resin viscosity during impregnation. Subsequent to, or during, curing the alkoxide will be hydrolyzed to precipitate small particles of metal oxide, such as zirconia or titania. These precipitates will increase the modulus and compressive strength of the resin and also of the solid free-formed component. Phase I will demonstrate a working system that will directly read a computer CAD drawing of a component and then generate the actual composite part with particulate reinforcements grown in situ. Phase I will include development of slurry formulations, optimization of the slurry delivery and injection system, and development of operating parameters.

Potential Commercial Applications: This technology will enable fabrication of complex parts with rapid prototyping and very low set-up cost and will have tremendous commercial potential as it will allow for smaller, lighter weight components with improved thermal capabilities.

***

086 MSFC
92-1-04.27-8600 NAS08-39804
Neural Processing for Weld Sensors
Applied Research, Inc.
P.O. Box 11220
Huntsville, AL 35814-1220
Larry Z. Kennedy (205-922-8600)

An investigation of the feasibility of neural processing for weld-sensor video will be performed. Fuzzy logic will be developed for weld system control. These techniques offer robust and real time processing potential for imagery which is difficult to make robust with "first principles" algorithms.

Potential Commercial Applications: Potential commercial applications would be in the area of high-technology welding.

***

087 LaRC
92-1-04.28-0435 NAS01-19890
High-Performance, Superconductor, Thick Films for Sensors and Detectors
Illinois Superconductor Corporation
1840 Oak Avenue
Evanston, IL 60201
James D. Hodge (708-866-0435)

The goal of this project is to produce thin-film-quality, high-temperature, superconductor (HTSC) sensor and detector leads using a new thick-film process. This process, by using inexpensive processing equipment and starting materials, promises to reduce by several orders of magnitude both the capital equipment investment and projected part costs required to produce thin-film-quality HTSC components. In addition, the

process is not substrate-specific and can be used effectively on a variety of substrate materials.

Potential Commercial Applications: The technology would be directly applicable to the fabrication of HTSC interconnects for electronic packaging applications. Such HTSC interconnects are attractive because of increasing interest in cryogenically cooled CMOS devices. "Hybrid" electronic packaging concepts may be possible where superconducting interconnects will be incorporated into cold CMOS systems for an incremental performance advantage with no additional cooling costs.

***

088 LaRC
92-1-04.28-2010A NAS01-19884
A Pinning-Phase Purification Process to Produce Useful Bulks of High Temperature Superconductors
HiTc Superconoco
P.O. Box 128
Lambertville, NJ 08530
Roland R. L. Loh (609-397-2010)

High temperature superconducting (HTS) materials are rapidly approaching expected performance levels in both film and bulk forms. This project addresses the development of two techniques for forming oriented, high-pinning crystal alignments using material produced by the firm's pinning-phase-purification (3-P) technique. The technique starts with melt texture growth generated powder, which is subsequently magnetically pinning-site refined to provide phase-pure, clean grain boundary bulk materials. 3-P powder is non-reactive and permits the use of binders to assist in the forming process. Unlike previous attempts at magnetic field forming using shake and bake' powders, this technique will combine low-temperature forming and high-pinning powder with an LN_2/alcohol slush binder in a steel die. The die will be placed in a magnetic field to create preferred orientation grains that will then be hydraulically compacted. The firm will also adapt its ceramic-fiber spinning technique to form continuous HTS multi-filaments, under 10 microns in size, and with mechanically aligned crystals (from extrusion through a fine spinerrette) along the 'c' axes. Phase I will develop and evaluate HTS materials in rudimentary bulk and fiber form. Phase II will test and deliver functional levitation stages, wound HTS fiber coils, high R_s cavities, and application-oriented, transport-current leads .

Potential Commercial Applications: Markets for HTS materials are expected to materialize in 3-5 years. The largest market will be for materials in bulk form and in wire (fiber) form.

***

089 JSC
92-1-04.29-0003 NAS09-18865
Optical Waveguide Solar Energy System for Lunar Material Processing
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Takashi Nakamura (508-689-0003)

This project will develop an optical waveguide (OW) solar energy system for lunar material processing. In this system, solar radiation is collected by the concentrator, which transfers the concentrated solar radiation to the OW transmission line consisting of low-loss optical fibers and related optical components. The OW line transmits the high-intensity solar radiation to the thermal reactor of the lunar material processing plant. The system features highly concentrated solar radiation (10,000 suns) that can be transmitted via flexible OW lines directly into the thermal reactor for material processing. The solar radiation intensity or spectra can be tailored to specific materials processing steps, and solar energy can be provided to locations or within enclosures that would not otherwise have access to solar energy. Furthermore, the system can be modularized and easily transported to and deployed at the lunar base. The project calls for identification of operation requirements for lunar material processing plants, analysis of key components of the OW solar energy system, conceptual design of the system for performance evaluation and feasibility assessment, and design of a proof-of-concept model of the system to be built and tested in Phase II.

Potential Commercial Applications: The OW solar energy system will be useful for a variety of in-space material processing applications. Potential terrestrial applications of the system include toxic waste destruction, metal refining, and surface treatment and conditioning.

***

090 JSC
92-1-04.29-1992A NAS09-18836
Carbothermal Reduction of Lunar Materials for Oxygen Production on the Moon
Orbital Technologies Corporation
402 Gammon Place, Suite 10
Madison, WI 53719
Sanders D. Rosenberg (608-833-1992)

A lunar oxygen plant will be developed based on site-independent, cyclic, carbothermal process which will use only resources found abundantly on the Moon. The project's primary objectives are to develop the design and operational approach for a lunar oxygen plant based on the three-step cyclic process for the production of propellant oxygen and useful by-products, such as iron, silicon, alumina, and magnesia. The critical knowledge required to build and test a prototype subscale plant for lunar oxygen production will be developed based on the innovative carbothermal process.

The project will culminate with the development of a preliminary design for a fully integrated plant and will recommend a program for Phase II.

Potential Commercial Applications: The carbothermal process is also applicable to gas production from coal gasification.

***

091 JSC
92-1-04.29-3260C NAS09-18866
Vacuum Separation of Oxides for Lunar Processing to Produce Metals and Oxygen
EMEC Consultants
R.D. 3, Roundtop Road
Export, PA 15632
Rudolf Keller (412-325-3260)

The production of oxygen and structural materials from extraterrestrial resources is an essential part of the U.S. space program. This project will investigate the feasibility of a vacuum treatment of lunar oxides to either beneficiate the prospective ore or, preferably, to separate a feed for a simple process yielding oxygen and metal. In particular, the project will examine the preparation of iron oxide to be further processed into oxygen gas and metallic iron. In this envisioned process, mineral oxides are volatilized and recondensed at relatively moderate temperatures. This approach is new, but its fundamentals have been previously studied as a geochemical phenomenon.

Potential Commercial Applications: Applications include the commercial production of lunar oxygen and iron, the treatment of unconventional terrestrial ores, and the treatment of waste materials such as fly ash.

***

092 JPL
92-1-04.30-0533 NAS07-1217
Development of an Integrated Health Monitoring System for Composite Structures
Innovative Dynamics, Inc.
95 Brown Road, Langmuir Labs M.S. 244
Ithaca, NY 14850-1252
Gail A. Hickman (607-257-0533)

The safety and reliability of composite structures depend upon the development of sensors to monitor structural health. Advanced "smart skin" systems will provide warning of such hazards as disbonding, impact damage, and subsequent damage growth. Under a multi-phase project, the company is developing an integrated health monitoring system for retrofitting aircraft structures using vibration signature analysis techniques. This research will be advanced to the next stage of embedded systems. Phase I will evaluate techniques for embedding sensors and actuators within a composite. A smart composite panel with embedded sensors and actuators will be constructed and interfaced with existing processing electronics to determine overall health monitoring performance. A detailed evaluation of either embedding the processing electronics within the composite or modularizing them into an external patch will also be performed. Phase II will develop the optimal configuration into a full-scale, space-durable system for future space experiments.

Potential Commercial Applications: Commercial and military vehicles may be able to significantly extend their useful life by properly monitoring the vehicle's health using a "smart" structure sensory system to detect such hazardous conditions as ice accretion, spin/stall conditions, corrosion and fatigue cracks, and impact damage. This technology may also find application in structures such as elevators, buildings, ships, storage tanks, and dams.

***

05: Teleoperators and Robotics

093 MSFC
92-1-05.01-4035 NAS08-39825
Control of a Flexible Manipulator During Re-Orientation of the Payload
Dynacs Engineering Company, Inc.
34650 U.S. 19 North, Suite 301
Palm Harbor, FL 34684
Sivakumar S.K. Tadikonda (813-784-4035)

The link flexibility in long slender arms connecting two large payloads is often modeled using a modes approach, where it is assumed that the mode shapes do not vary with time. However, several maneuvers of an articulated flexible manipulator, such as the space station remote manipulator system (SSRMS), result in a variation in the component structural frequency by as much as 400 percent. This variation only occurs when the boundary conditions of the component structure are charged and not because of large overall motions. This project will develop a dynamic model to demonstrate the changes in the structural characteristics and will design a controller to account for the frequency changes during a re-orientation of the payload. Re-orientation consists of a large-angle maneuver of a one-link, flexible manipulator pinned at one end and a large payload attached at the other. The controller is based on an inverse-dynamics, feed-forward loop, and a robust controller in the feed-back loop. The SSRMS, as well as other NASA projects which contain articulated flexible multibody systems, will benefit from the dynamic modeling approach and the controller design.

Potential Commercial Applications: The results of this project will assist the development of a low-cost dynamics analysis tool for industries and universities.

***

094 MSFC
92-1-05.01-5600 NAS08-39805

Real-Time, Video Perspective Modification for Effective Cancellation of Communication Time Delay In Vehicle Teleoperation

Telerobotics International, Inc.
7325 Oak Ridge Highway, Suite 104
Knoxville, TN 37931
Steven D. Zimmermann (615-690-5600)

Communication time delay and low video bandwidth produce slow scanned imaging (one frame every 3-5 seconds), making teleoperation of remote vehicles very difficult. This project addresses this challenge by applying a patent-pending video technology (Omniview), in combination with vehicle dynamic simulation, to allow realistic teleoperation by video emulation tweening (VET). The objectives are to use Omniview to capture a slow, scanned image at a 30-frames-per-second output, effectively providing the operator with real-time perception of the vehicle operation, simulating turning (pan), climbing (tilt), forward motion (magnify), and tipping (rotate). While the latest picture is being scanned into the input buffer, the system is using the previous image and the operator commands to simulate the vehicular motion in video with no time delay. After 4 seconds have progressed, the next image is used as the input, and the tweening based on vehicular motion is repeated. Phase I includes a demonstration with available subsystems to verify that vehicle teleoperation with VET is feasible. Phase II will develop a virtual reality unit capable of application to slow scan video reconstitution or discrete geographic video grids for ground or airborne vehicular simulation.

Potential Commercial Applications: This system would have application to NASA-planned activities, such as the lunar or Mars rovers. It would also be useful in many time-delayed remote operations, aircraft simulators, and vehicle teleoperation training.

***

095 JSC
92-1-05.02-1555 NAS09-18869

High-Performance, Programmable, Compliant Manipulators

Nastec, Inc.
1111 Ohio Savings Plaza, 1801 East Ninth
Cleveland, OH 44114
William J. Anderson (216-696-5157)

This project addresses the analytic design and acquisition of test data leading to the development of a robot with dramatically superior manipulation capability. The key element is the use of roller-gear drives, in which smooth rollers provide backlash-free, low-friction, extremely smooth forward and reverse torque scaling, while parallel conventional gears augment the rollers to increase the maximum output torque. Two prototype drives were constructed for NASA for evaluation as low torque-ripple devices for microgravity mechanisms. A peripheral assessment of one of the drives operating within a torque feedback loop demonstrated remarkably good performance under impedance control. In this project, one of the drives would be evaluated more extensively to characterize its potential as a high-performance robot joint. Using this information, a three-degree-of-freedom, all-revolute robot would be designed around these transmissions, which would be optimized for practical payloads and for high-performance programmable compliance. Fabrication and testing of the resulting design will be conducted in Phase II.

Potential Commercial Applications: High-performance, programmable, compliant robots which maintain high precision would find wide application in conducting manipulative tasks involving fragile objects and containers, in mapping surfaces and coordinates, and in handling hazardous materials. The technology advance also makes possible machines with increased payloads and less costly control systems.

***

096 JSC
92-1-05.02-4222 NAS09-18931

Intelligent Robotic Interpretation of Natural Language Instructions

Robotics Research Harvesting
166 Springdale Way
Redwood City, CA 94062
Marcel Schoppers (415-369-4222)

The innovation in this project is to integrate a state-of-the-art capability for intelligently controlling real robots with a state-of-the-art capability for understanding and obeying spoken instructions. Such an integration will be far in advance of anything previously attempted. The robots' natural language capability will also allow them to understand verbal input in a broader variety of instructional contexts than has ever been possible. The union of intelligent robotic control with spoken instructions is a prerequisite for practical deployment of crew-helper robots. These robots are the shortest and most effective path to reducing both the costs and the dangers of astronaut time in space. The specific technology to be used will also be applicable to robots on interplanetary voyages. Phase I will demonstrate existing capabilities for instructing animated agents in virtual worlds, will provide a preliminary integration of English input with the EVA retriever's intelligent control plan, and will specify the competence needed to allow predictable robotic help. Phase II will deliver a working software system to make free-flying robots intelligently follow spoken instructions.

Potential Commercial Applications: Self-propelling robots that can understand verbal instructions will be especially useful in space because they allow for less risk to humans, reduce human-time costs, and possess more physical strength. These benefits will also be attractive to military, mining, deep ocean, and demolition

operations. The company plans to license the resulting technology to robot manufacturers.

***

097 JSC
92-1-05.02-4222A NAS09-18861
Robotic, Whole-Body Dexterity and a Software Architecture for Task Performance in Uncontrolled Environments
Robotics Research Harvesting
166 Springdale Way
Redwood City, CA 94062
Marcel Schoppers (415-369-4222)

A robotic, whole-body dexterity and a software architecture for multi-limbed robotic systems that admits perception processing, while still guaranteeing hard real-time response, will be developed. Both innovations are critical to address NASA's need for robotic systems capable of mobility and manipulation in uncontrolled environments, especially to navigate space, planetary surfaces, corridors, and cramped areas, and also to achieve stable postures allowing the robot to reach into awkward spaces to replace malfunctioning parts. Phase I objectives will show that robotic, whole-body dexterity and real-time, model-based vision are feasible, while Phase II will show that they are ready for integrated deployment in real robots. The project will integrate state-of-the-art, real-time robotic motion planning (reconciling geometry, redundant degrees-of-freedom, torques, and moving obstacles) with a capability for on-line dynamics analysis. It will also separately embed a state-of-the-art image-understanding system into a software architecture which guarantees hard real-time control. The project will then bring the real-time motion and the real-time perception together to yield a capability for robotic, whole-body dexterity that supports task performance in uncontrolled environments such as space stations and lunar bases.

Potential Commercial Applications: The capability for robotic, whole-body dexterity in uncontrolled environments will initiate a new generation of self-propelling assistant robots. The arguments for using such robots in space (less risk to humans, less cost of human time, robotic strength) apply also for military, mining, deep ocean, and demolition operations. The company plans to license the resulting technology to robot manufacturers.

***

098 JSC
92-1-05.02-9546 NAS09-18926
Distributed, Autonomous Robotics Integration System for Space Applications
Modulus Technologies, Inc.
1916 Carroll, Suite 4
Houston, TX 77030
Lawrence A. Ciscon (713-797-9546)

An environment for integrating and managing distributed, autonomous robotics systems will be designed and implemented. The supervisory system will provide rapid prototyping, status and information monitoring, and dynamic reconfiguration of autonomous robotics systems operating over extraterrestrial distances. Heterogeneous software and hardware systems will be coordinated within the environment, with the actions of several robotics systems coordinated simultaneously. The environment will itself be a distributed program, thereby allowing several operators to supervise robot activity and to pass control among them. A prototype system will be developed over a six-month period by company staff in coordination with NASA personnel. The system is expected to provide an extensible, fault-tolerant management environment for autonomous robots in space applications and to lead to a sustained, but modifiable, supervision system for combined man-robot missions.

Potential Commercial Applications: Applications include the management of flexible manufacturing facilities, process control systems, distributed database systems, home automation, and offices.

***

099 JPL
92-1-05.03-0402 NAS07-1205
A Piezoelectric, Crawling Minirobot
Bonneville Scientific, Inc.
918 East 900 South
Salt Lake City, UT 84105
Allen R. Grahn (801-359-0402)

This project investigates an insect-like robot that uses linear and rotary piezoelectric motors for actuating the limbs and end-effectors. The piezomotors are low-mass, high-energy-density devices that do not require transmissions to meet the speed and torque requirements for miniature robots. Moreover, these motors use redundant actuators which provide a degree of fail-safety, and they have a built-in, powerful brake which consumes negligible energy. The envisioned minirobot will have two prehensile legs having six-degrees-of-freedom (for positioning end-effectors). Integrated tactile and force-torque sensors can be used in guiding and testing foot placement and detecting contact with obstacles. When walking on smooth surfaces, the tactile sensors in the soles of the feet can be used to determine adequate coverage of a volatile, sticky fluid secreted through pores in the soles for providing adhesion to the surface.

Potential Commercial Applications: Small, self-contained, crawling robots will have a wide variety of commercial applications, including reconnaissance during disasters (earthquakes, building fires, explosions), surveillance, security, inspection, sample collection, and retrieval.

***

100 JPL
92-1-05.03-7830 NAS07-1236
Mini-Robot Rover
Omnitech Robotics, Inc.
6448 South Parfet Way
Littleton, CO 80127
David W. Parish (303-933-7830)

This project will develop a mini-rover that incorporates an array of innovations, such as mechanics suitable for space and earth applications, a walker-locomotion system that provides three degrees-of-freedom from only three actuators, a multipurpose foot-contact pad, and a free-flying capability using nitrogen gas thrusters for locomotion in space. The main contributions consist of mechanical design, electronics and controls system design, sensors selection, autonomous architecture design, and overall integration.

Potential Commercial Applications: Commercial applications include Department of Energy waste tank inspection, Federal Aviation Administration aircraft fuselage inspection, and marine application for ship hull inspection.

***

101 JPL
92-1-05.03-9570 NAS07-1226
Mini-Robotic-Arm System for IVA Experiment Servicing
Robotics Research Corporation
P.O. Box 206
Amelia, OH 45102
Keith A. Kowalski (513-831-9570)

Miniature robotic manipulator systems, designed to automate repetitive experiment tending and similar IVA servicing duties aboard Space Station Freedom, could increase crew efficiency during astronaut-tended operations and provide a means to maintain experiments remotely from Earth. Articulated manipulators, approximately 500-700 millimeters in length, are envisioned to work at fixed locations in the laboratory module and support material and life science experiments. Although intended only for IVA applications, this new class of mini-robots must be designed in a form suitable for flight-qualification, with a basic design which affords lightweight and low-power requirements, and which incorporates those features demanded by NASA safety and reliability standards. This project aims to develop and demonstrate a mini-robotic-arm system which meets the functional requirements for IVA experiment tending in the laboratory module and employs a design that could be flight-qualified. Since different levels of dexterity may be needed for different installations, the system will be designed to be configurable, such that a family of arms–number of joints and kinematic arrangement–can be assembled from the same set of qualified modules to fit specific experiment requirements.

Potential Commercial Applications: This research will expand the use of laboratory robots and teleoperators in tending biological experiments and processing pharmaceuticals on Earth; provide automation of routine servicing tasks (greenhouse tending, animal specimen cage servicing) and production tasks in controlled environments; and provide teleoperated manipulation and inspection of hazardous biological specimens and chemical samples in quarantined environments.

***

102 JPL
92-1-05.04-4511 NAS07-1220
Multi-Sensory, Feature Recognition Networks for Space Robotics
Standard International, Inc.
4040 Spencer Street, Suite A
Torrance, CA 90503
Shaomin Zhou (310-371-4511)

In space robotics and teleoperator systems, communication delays, limited resources, and the inaccessibility of human manipulation require the design and development of increasingly intelligent, built-in robotics-pattern-recognition and classification capabilities. The innovation of this project is found in the capitalization of the massive parallelism of optics and the advanced algorithms of neural networks. The objective is to create a multi-sensory, space robotics, target-recognition-via-feature-extraction, and a neural-associative-retrieval network which is expandable to an aggregate throughput up to the order of terabits/second. This approach is based on principles of neural association and optical correlation architectures. Successful results will display a high-level capability of optically multiplexing each input and comparing this input with many different reference matrices. Through a convergent, nonlinear, optical-thresholding process, this technology will produce an oscillatory, optical-resonance mode where input variation and error is eliminated in the reconstructed output.

Potential Commercial Applications: Commercial applications include parallel database search; image and signal understanding and synthesis; robotics manipulation and locomotion; natural language processing; and real-time, multi-sensory target recognition.

***

103 GSFC
92-1-05.05-0661B NAS05-32423
A Cableless Joint for Space Robotic Manipulators
Honeybee Robotics
204 Elizabeth Street
New York, NY 10012
Thomas Myrick (212-966-0661)

This project concerns the development of a modified, planetary, gear-based cableless joint capable of transferring electrical signals and power across continuously rotating robotic or mechanism joints similar to slip

rings but without their many limitations. In addition to surpassing the performance of general slip rings, the electrical transfer elements will also transmit torque, fostering a more compact design. The effort will determine the feasibility of transmitting signal and power through the cableless joint in a practical setting, investigate the torque transmission potential of the joint, design in detail a first iteration of the cableless joint, and fabricate and test a comprehensive breadboard version of the design. The research should lead to increased signal and power transfer capabilities of NASA mechanisms currently employing slip rings and to the removal of the main limitations of slip rings. The innovation will also foster the development of new types of high-performance robotic manipulators and other spacecraft mechanisms.

Potential Commercial Applications: Cableless joints will find direct application in the future design and construction of improved automotive transmissions, commercial robot wrists, and satellite solar array and antenna mechanisms. Many other commercial mechanism designs could be generated by the advent of a cableless joint.

***

104 JSC
92-1-05.06-0402 NAS09-18856
Sensor-Based Control for a Piezoelectrically Operated Dexterous Hand
Bonneville Scientific, Inc.
918 East 900 South
Salt Lake City, UT 84105
Allen R. Grahn (801-359-0402)

This project will investigate and develop control techniques for the company's miniature dexterous hand currently under development for NASA. This hand uses high-energy-density piezoelectric motors to achieve direct-drive of the digit segments. These motors have unique characteristics and unconventional modes of operation which can provide important advantages over conventional motors. The goal of this project is to research and develop a low-level control system for the hand's piezomotors. Phase II will develop high-level, tactile-sensor-based control of the hand using the scheme developed in Phase I. The successful completion of this project will result in the development of a human-scale, robotic hand and controller with integrated tactile sensing, which will be suitable for adaptive grasping, manipulation, force and slip sensing, and haptic exploration.

Potential Commercial Applications: The dexterous hand system can be used in advanced robotic and telerobotic applications. Other uses include manufacturing, prosthetics, laboratory studies in dexterous manipulation and grasping, aides to the handicapped, and service industry robots.

***

105 JSC
92-1-05.06-2567 NAS09-18855
Whole Arm and Hand-Finger Force Reflecting Masters
Cybernet Systems Corporation
1919 Green Road, Suite B101
Ann Arbor, MI 48105
Charles Jacobus (313-668-2567)

Force reflection substantially improves teleoperated and virtual reality systems. A force-reflecting hand and fingers system will be developed, which will be coupled to a mature, six-axis, force-reflecting master. This combined system provides ideal control for a teleoperated robot and its attached multi-fingered dexterous manipulator. The advantages of this approach and concept over previous efforts in this area are: the dexterous manipulator device will only be moderately complex, translating into low cost and high reliability; the physical size and weight of the device will be small; the approach will allow the device to accommodate a wide range of operator wrist, palm, and finger sizes; and the project will be highly focused because the effort needs only to develop a dexterous master for the operator's hand and fingers.

Potential Commercial Applications: A force-reflecting arm and/or hand master controller would be of great use in hazardous environments (toxic chemicals, nuclear radiation, disease carrying materials), space-based applications, construction, and the medical profession (e.g., microsurgery, where large movements could be scaled down to smaller movements while preserving the haptic cues).

***

106 LaRC
92-1-05.07-3200 NAS01-19889
Truss Climbing Robot
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Richard Fontana (617-890-3200)

A miniature, self-contained, modular robot capable of climbing on the members of truss structures will be developed. It will be able to negotiate the nodes of a truss and can serve a dual function as a manipulator arm. The robot could perform non-destructive testing of the truss members and large, smooth-curved structures mounted on or near the truss. The robot could also deploy instruments, retrieve samples, build structures, and perform simple repairs. This robot will safely perform repetitive, dangerous and difficult tasks that would otherwise waste valuable astronaut-EVA time. The mini-robot will be smaller, safer, and more versatile than any existing space robot designed to perform similar functions. Phase I will result in a layout of the system, including the mechanical components, sensors, communications and controls. Phase II will produce a working prototype.

Potential Commercial Applications: The self-contained truss climber's ability to move autonomously through a truss and also act as a manipulator arm makes it ideal for a variety of commercial uses. Inspection or light-duty manipulative tasks such as installation, repair, or cleaning can be performed anywhere human access is difficult or dangerous. The robot can be adapted to work on any truss or lattice and can inspect bridges, towers, buildings, and cranes.

***

107 LaRC
92-1-05.07-9200 NAS01-19873
Advanced, Coherent Laser-Radar-System Components
Coleman Research Corporation
5950 Lakehurst Drive
Orlando, FL 32819
Anthony Slotwinski (703-719-9200)

Phase I will investigate the feasibility of developing an electro-optically tunable, miniature, solid-state laser and a miniature, fiber-optic-coupled, automatic focussing lens for use with robotic-coherent, laser-radar vision- and proximity-sensing systems. Systems equipped with such components will be small, lightweight, flexible, and compatible with robotic end-effectors for sensing and control applications. These components will provide for longer range more sensitive and accurate sensing than is currently possible.

Potential Commercial Applications: Potential applications are in the areas of factory automation, robotic sensors, process control, non-contact sensing and gauging, and coherent communications.

***

06: Computer Science and Applications

108 ARC
92-1-06.01-4562 NAS02-13805
Autosteroscopic Video Monitor for Computer Graphics
Perceptual Images
15951 Los Gatos Boulevard, Suite 7
Los Gatos, CA 95032
John L. Miller (408-356-4562)

This project will develop computer monitor that allows the viewer to see a full-color, full-motion image in three dimensions, with motion parallax. and without the need for viewing glasses. The concept for this display is based on relaying a CRT image onto a back-to-back lenticular viewing screen. The relayed image passes through a large diameter optical system and a liquid-crystal shutter array. The shutter is synchronized to the CRT refresh rate to pass light from the CRT to the viewing screen through multiple horizontal shutter positions, thus allowing light to strike the rear-facing lenticular surface at a specific angle relative to the open shutter position. By switching the shutter and CRT at a rate above which flicker is noticed, a composite three-dimensional image is formed on the viewing screen. The observer views the composite image through the forward-facing lenticular from a distance of about 24 inches. The sequential-view, autostereoscopic monitor will provide the scientist with more tools to analyze complex phenomena, which can be modeled with computers. This monitor will allow the viewer to use depth perception and motion parallax along with color and motion as tools for scientific visualization. Phase I calls for image simulation and component selection for the monitor.

Potential Commercial Applications: This monitor can be used for computers, radiographic inspection, radar, remotely piloted vehicles, medical displays, television, and virtual reality.

***

109 ARC
92-1-06.01-4807 NAS02-13802
A C++ Virtual, Shared-Grid Model for Architecture-Independent Programming
Front Range Scientific Computation, Inc.
Campus Box 170, P.O. Box 173364
Denver, CO 80217-3364
Daniel J. Quinlan (303-556-4807)

This project will investigate the P++ user environment to simplify the development of efficient software for portable use across the widest variety of computer architectures. The major target architectures are distributed memory computers with different kinds of node architectures (vector or superscalar). A simplifying environment for the development of software is needed to take advantage of current and future developments in advanced computational hardware which the P++ environment does by using a standard language, C++, with absolutely no modification of the compiler. Such work is directly related to development of runtime parallel interpretation for FORTRAN 90 D. The advantage of using a standard C++ is that the runtime interpretation of parallelism can be more quickly developed and researched without the construction of a special FORTRAN compiler thereby allowing for the runtime parallel interpretation of FORTRAN to be explored with greater efficiency than would otherwise be possible. Such work also extends the usage of the object-oriented C++ language for development of architecture-independent numerical codes. Such an environment would allow existing C++ language compilers to be used to develop software in the preferred serial environment, and the software could be efficiently run, unchanged, in all target environments. In this way, the investigators introduce an innovative development to permit architecture-independent programming for large-scale scientific applications, which is directly related to existing NASA work on FORTRAN for the parallel environment.

Potential Commercial Applications: This work will simplify the development of software for advanced computers and will be made generally available as a commercial product through Dyad Software Corp. and Pallas GmbH product lines of tools for the support of scientific programming. Additionally, the runtime environment will be provided a FORTRAN interface that will permit the direct incorporation of the P++ environment into the design of the FORTRAN 90 D compiler.

***

110 LaRC
92-1-06.01-9457 NAS01-19893
A Knowledge-Based System for Analyzing Technical Data
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Laura C. Rodman (415-968-9457)

Recent technical advances have made numerical simulations of physical phenomena very efficient at generating large amounts of data. In some fields, the inability to analyze all the collected data may impede the understanding of increasingly complex phenomena. The goal of this project is to produce an automated technique that will filter large amounts of data in order to identify interesting trends and relationships. This approach uses knowledge-based systems to replicate the reasoning steps that would be taken by an investigator to find trends and relationships in a set of data. For example, the program can look at the sensitivity of a quantity to other variables in the data, or for strong correlations among specified quantities. The automation of this process would allow very large amounts of data to be studied much more rapidly than is currently possible, and may allow the discovery of certain trends that might have been otherwise missed. This system will filter through data more quickly in order to pinpoint areas of interest so that the scientist can concentrate on studying those particular areas.

Potential Commercial Applications: This project addresses a critical need to analyze more efficiently large quantities of data. Potential aerospace applications are in computational fluid dynamics, satellite imaging, and ground testing.

***

111 GSFC
92-1-06.02-4881 NAS05-32401
Icon Code Environment
Advanced Technologies, Inc.
34054 U.S. Highway 19 North, Suite 368
Palm Harbor, FL 34648
Mark Gardinier (813-391-4881)

This project will develop a new method of creating system-software applications–the icon code environment (ICE). ICE will greatly benefit NASA's flight control software for space missions. Development of software from traditional flight-control diagrams has resulted in the identification of numerous difficulties with performance, maintenance, documentation, and integration testing. The problem of block-diagram changes, which result in dramatic changes to the structure of the code, has caused significant cost and schedule impacts for verifying and validating the flight control software. Compounding the problem is the need for software developers to build custom software development environments for each unique set of requirements.

Potential Commercial Applications: The icon code environment, which is independent of target processor, software languages, and software toolsets, can be used by commercial developers of any type control system.

***

112 GSFC
92-1-06.02-8817 NAS05-32406
Methodology and Mapping Between Problem Requirements and Solution Scheduling Approaches in Mission-Planning Expert Scheduling Systems
American Minority Engineering Corporation
10422 Armory Avenue
Kensington, MD 20895
Jay Liebowitz (301-933-8817)

Expert scheduling systems are successfully being used in a variety of aerospace industry applications, including scheduling the requests for NASA Goddard-supported satellites. Even though expert scheduling systems are being used at Goddard and other NASA centers, an important and troubling question that many Goddard managers involved in expert systems are asking is, "When is it most appropriate to use a particular scheduling approach in an expert system?" This project will map requirements to scheduling approaches for use in mission-planning expert scheduling systems. The answer to this question will lead to software reusability and could save Goddard and NASA thousands of dollars.

Potential Commercial Applications: This project could lead to the development of an expert system which will first assess the situation and then select the appropriate scheduling technique based on the requirements of the scheduling problem.

***

113 LaRC
92-1-06.03-1219 NAS01-19896
Quantifying Confidence in the Correctness of Parallel or Distributed Software
Reliable Software Technologies Corporation
1001 North Highland Street, Penthouse Suite
Arlington, VA 22201
Jeffrey M. Voas (703-276-1219)

This project will develop a new technique for assessing the testability of parallel/distributed software systems. Since many critical software systems are being considered for deployment in parallel or distributed environments, and since the need for extremely high levels of reliability exists, there must be a feasible means of assessing reliability. Non-exhaustive, random black-box software testing is frequently used for demonstrating system reliability but is generally infeasible for high levels of reliability. This project addresses whether particular software systems can be tested to high levels of reliability by predicting whether the testing has missed hidden faults. This is an improved technique for assessing how confident a developer is in a software's reliability. The project's objective is to augment a software testability model created for sequential software systems and apply it to parallel or distributed systems. Anticipated results are a complete model for assessing the testability of parallel or distributed systems.

Potential Commercial Applications: The benefit of testability analysis, both for sequential and parallel or distributed systems, is its power to reveal whether even thoroughly tested software is still hiding faults although testing has suggested the contrary. This analysis will benefit the commercial development of software by reducing the likelihood of undetected faults.

***

114 LaRC
92-1-06.03-3370 NAS01-19904
System for Effective Evaluation of Requirements
Software Productivity Solutions, Inc.
122 4th Avenue
Indialantic, FL 32903
James N. McGhan (407-984-3370)

Phase I will focus on the definition of a comprehensive requirements analysis process that eliminates errors through automated verification of the requirement set, testability analysis, and traceability control. The system for effective evaluation of requirements (SEER) methodology will demonstrate that the requirements verification process, when applied to a large-scale software system, provides a solution that exhibits the potential for ensuring correct software, delivered on time and within budget. This project will define methods, techniques, and tools which can dramatically improve the software requirements process. SEER is a systematic approach for testability analysis and a formal verification of software specifications. SEER will also provide visibility and valuable process status feedback to software managers, developers, and assurance engineers. The firm's research in current requirements verification methodologies and natural language processing techniques has resulted in an innovative integration of technologies that exhibit a high potential for increasing the correctness of a software product while reducing cost and risk. SEER will define specifications for tools which incorporate expert system technology that can be integrated with existing project toolsets and databases.

Potential Commercial Applications: The firm's requirements optimization techniques, requirements verification approach, and automated toolset will improve the reliability of mission-critical software and commercial applications with stringent accuracy requirements, such as the finance and banking communities, commercial avionics, air traffic control, and nuclear power industries.

***

115 JSC
92-1-06.03-6871 NAS09-18831
Feasible Path Analysis for Ada Test Case Generation
Kestrel Development Corporation
3260 Hillview Avenue
Palo Alto, CA 94304
Allen T. Goldberg (415-493-6871)

The use of a theorem prover to aid automated test case generation of Ada programs will be explored. A theorem prover is used to determine if a control flow path, or a class of control flow paths, is feasible. Control path feasibility is in turn used to minimize test set size and to establish that test sets meet coverage criteria. This project will build upon the company's work in scaling analysis to production programs which are closely related to flight-critical systems. One such analytical tool is the Ada testing workbench (ATW), jointly developed by Kestrel and Reasoning Systems. This project will extend the capabilities of the ATW to process larger-sized Ada procedures, extend the Ada subset it uses, and provide automatic test case generation from test specifications.

Potential Commercial Applications: An Ada structural testing tool will minimize the test set size and will generate high-quality test cases in which the user is assured of coverage.

***

116 JSC
92-1-06.04-7979 NAS09-18839
Ontology-Driven Information Integration
Knowledge Based Systems, Inc.
P.O. Box 9930
College Station, TX 77842
Paula S. Dewitte (409-696-7979)

Useful integration of information from heterogeneous knowledge bases requires both a platform for access to the information and intelligent support for the interpretation of the acquired data within the frame of reference of the target application. Building on the DARPA Ontolingua and the Air Force IDEF5 technology, this project will explore the use of domain specific ontologies as the basis for constructing intelligent information integration mechanisms. These mechanisms would make easier locating and accessing relevant information as well as fusing and applying the shared data.

Potential Commercial Applications: These mechanisms can be used in electronic commerce networks, concurrent engineering, corporate information management, flexible computer-integrated manufacturing, and agile manufacturing.

***

117 ARC
92-1-06.04-9915 NAS02-13788
A Knowledge-Based System Developer for Aerospace Applications
ERC, Inc.
205 Research Park Drive, P.O. Box 417
Tullahoma, TN 37388
Y.C.L. Susan Wu (615-455-9915)

A knowledge-based system developer (KBSD) will be developed that can be utilized to acquire knowledge directly from domain experts and to extract heuristic rules from that knowledge in aerospace application fields. A KBSD will raise the state-of-the-art of knowledge acquisition and expert system technology by removing the need for knowledge engineers. The primary research will be directed to solve the knowledge acquisition, verification, validation, rule extracting, knowledge presentation, and database integration problems using artificial intelligence technology, including dynamic interfaces, expert systems, and hypertext. Phase I will design and implement a prototype KBSD on a Macintosh computer using selected knowledge from the Project Engineers' Intelligent Assistant, an existing knowledge-based system recently developed at the NASA Ames Research Center. Phase II will refine and develop the prototype KBSD into a fully functional software shell and extend it into a more general software tool applicable to all aerospace applications.

Potential Commercial Applications: The resulting software will help NASA to preserve its domain-experts' knowledge and increase the productivity of NASA personnel. The KBSD software shell could also be used commercially as a repository for all types of knowledge.

***

118 JSC
92-1-06.05-5700 NAS09-18828
Virtual Reality Software Toolkit
Lincom Corporation
1020 Bay Area Boulevard, Suite 200
Houston, TX 77058
J. Mark Voss (713-488-5700)

A rapid-prototyping software environment for virtual reality (VR) applications will be developed. This project will address the need for VR software development tools to allow the technology to be integrated into engineering applications. The objectives of Phase I include the definition and architectural design of the VR application toolset that will consist of a graphical model builder, hardware I/O module library, networking library, user interface and a code generator. Phase I will specifically address these areas and extensively document the software design in preparation for Phase II. The expected NASA applications are in utilization of VR for astronaut training and engineering part-task simulator analysis and training. Astronauts and engineers will be able to train and evaluate space systems while feeling as if they are in the environment. This technology will both provide a more realistic training environment and reduce costs.

Potential Commercial Applications: Potential commercial applications of this project include telepresence and telerobotics that will allow robotic devices to be controlled from remote locations, will enhance medical research and education by allowing students to enter a virtual human body, and will create entertainment and interactive virtual-reality videos.

***

119 JSC
92-1-06.05-5700B NAS09-18870
Loss-Tolerant Speech Coding for Manned Space Flight
Lincom Corporation
1020 Bay Area Boulevard, Suite 200
Houston, TX 77058
Jaime Prieto (713-488-5700)

Manned-space-flight speech communications are vital to ensure mission success and crew safety. Mission goals are compromised when speech communications are interrupted by environmental and man-made noise on the space network. Noise can cause loss of information and decoder failure in reproducing the original coded speech. Conventional digital speech coding algorithms do not maintain high-quality audio in the presence of information loss. The goal of this project is to develop a real-time, loss-tolerant speech coder for manned space flight where a high degree of speech

quality and intelligibility is maintained in the event of speech data loss. Space-time neural network (STNN) technology in tracking and predicting the time-frequency energy content of speech will be incorporated as the first step of the project. The STNN effectively models spatial-temporal relationships and the loss-tolerant speech coder using STNN represents a breakthrough in speech communications for manned space flight.

Potential Commercial Applications: Potential applications include integration of speech communications with other services on packet networks. The prime candidates for this technology are channel sharing on telephone lines, meteor-burst speech transmission, cellular telephones, aviation communications, and global satellite communication networks.

***

120 JSC
92-1-06.05-7979 NAS09-18849
Knowledge-Based Mechanisms for Plan Generation
Knowledge Based Systems, Inc.
P.O. Box 9930
College Station, TX 77842
Benjamin Perakath (409-696-7979)

The increasing complexity of task planning for aerospace applications has led to the need for improved systems to coordinate multiple activities in diverse application areas. A plan is useful when it can identify the precise requirements of activities and accurately represent the complex interactions between multiple agents working to achieve mission objectives. This project will use descriptions to develop knowledge-based support for planning. The Air Force IDEF3 description-capture-support method will be used as the basis for plan knowledge capture and representation. The project will develop mechanisms to validate descriptive knowledge relevant to process plans and will investigate the constraint propagation paradigm as a mechanism to propagate the effects of plan changes made in a dynamic environment. As a last step in the plan validation process, a plan simulation analysis mechanism will be developed which will visually present alternative plan scenarios. The project will provide an adequate testbed for an innovative application of the IDEF3 method. The knowledge-based planning technology resulting from this project has the potential to benefit planning activities in many areas.

Potential Commercial Applications: The description-centered paradigm represents a new approach to knowledge-based planning and will benefit concepts and tools in project and product planning, systems simulation, and systems analysis and design.

***

121 JSC
92-1-06.05-8321 NAS09-18829
Improved Genetic Algorithm for Plan Scheduling and Optimization
New Light Industries, Limited
3610 South Harrison Road
Spokane, WA 99204
Stephen P. McGrew (509-456-8321)

Genetic algorithms have been shown to be superior to other approaches for finding global optima in large, complex multidimensional data spaces. Their strength is attributable to two features: their ability to sample quickly large volumes of solution space and their capacity for discovering features common to high-quality solutions and combining those features in novel ways. However, to date, genetic algorithms have been found to be less efficient than simple hill-climbing methods for finding optima in simple solution spaces. Current genetic algorithms often get trapped in local suboptimal solutions due to premature convergence. Furthermore, their capacity for discovering features common to good solutions is limited by a tendency to break up substructures more than a few genes long. A new genetic algorithm, one that corrects several deficiencies of past genetic algorithms by explicitly providing for the evolution of large gene substructures, has been developed. It provides for a genetic coding scheme that is self-optimizing for the problem at hand and combines the techniques of genetic crossover, mutation, and hill climbing with an overseer genetic algorithm module.

Potential Commercial Applications: This genetic algorithm will become a commercial-quality, user-friendly software package with a graphic user interface, designed to serve as a plug-in, general purpose optimizer for spreadsheets, scheduling programs, CAD/CAM programs, etc. Possible applications are in solving partial differential equations, game playing, architectural design, pattern recognition, CAD, and machine control.

***

122 ARC
92-1-06.06-8181 NAS02-13779
Analog Optical Vector-Matrix Computer
Photonic Systems, Inc.
1800 Penn Street, Suite 4B
Melbourne, FL 32901-2625
James A. Carter, III (407-984-8181)

Vector-matrix multiplication is a fundamental operation in the field of linear algebra. Since the development of the Stanford analog vector matrix-processor in 1978, substantial improvements have been made in optical components and in the field of optical engineering. High-performance, multichannel Bragg cells can now encode the vector data in real-time while matrix data can now be encoded by spatial light modulators in real-time. More importantly, the state-of-the-art in photodetector array and image acquisition technology has advanced to the point where packaged optical

processors can be used in instrumentation. For example, this project will build a high-performance, optical vector-matrix processor with 8-bit accuracy for optical computing research.

Potential Commercial Applications: The project's Phase II product, a high speed analog computer with accuracy equivalent to 8 bits, will have many commercial applications such as seismic data analysis and real-time data compression. Solutions to problems in aerodynamics or ultrasonic image processing will be more tractable with this computational device. Various high computing initiatives will study or integrate the analog vector-matrix computer into their systems.

***

123 ARC
92-1-06.06-8321 NAS02-13784
High-Resolution, High-Speed, Spatial Light Modulator
New Light Industries, Limited
3610 South Harrison Road
Spokane, WA 99204
Stephen P. McGrew (509-456-8321)

Improved spatial light modulators are needed to implement many of optical computing schemes. This project will develop a high-resolution, high-speed, spatial light modulator employing a zero-order, diffractive relief "AZTEC" structure. The device will be expected to attain a pixel diameter of 10 microns or less and could be configured to be addressed optically or electrically and to operate in either binary or analog mode.

Potential Commercial Applications: The AZTEC modulator can be incorporated into holographic stereogram printers currently being developed to increase production capacity and image quality. Additionally, the modulator can be used in optical computing, optical interconnects, video projection, and image processing.

***

07: Information Systems and Data Handling

124 GSFC
92-1-07.02-0101 NAS05-32432
A Computational Fluid Dynamics Package for Massively Parallel Supercomputing
Nektonics, Inc.
875 Main Street, 4th Floor
Cambridge, MA 02139
Einar M. Ronquist (617-868-0101)

Parallel processing offers exciting possibilities for computational modeling. This project will develop a general purpose, parallel computational fluid dynamics (CFD) software package which can perform large-scale fluid dynamics calculations for NASA and the aerospace and manufacturing industries. This package will ultimately run on advanced parallel MIMD supercomputers such as the Intel Gamma and Paragon series, the TMC CM-5, and next generation Cray based upon DEC's Alpha chips. Phase I activities will develop a parallel CFD code based upon the methods found in the spectral element general-geometry CFD code, NEKTON. This new code will incorporate the innovative features of generalized adaptive meshing, NURBS-based geometry modelling, object-oriented program and data structures, and fast parallel solution techniques. The company will demonstrate these features by solving CFD problems beyond the capability of current CFD technology. In Phase II this new code will serve as a basis for an advanced, comprehensive, parallel CFD tool to be delivered to NASA.

Potential Commercial Applications: A general purpose, accurate, and robust parallel CFD tool is important to airframe manufacturers, material processing industries, and any industries in which fluid flow is important. The advances in efficiency for parallel computation will enable the cost-effective solution of significantly more difficult problems in these industries. This parallel tool will enable industry to shorten their design cycles and improve reliability and competitiveness.

***

125 GSFC
92-1-07.02-3223 NAS05-32429
Parallel-Architecture-Based Feature Extraction and Sensor Fusion for Object-Oriented Image Database Operations
LNK Corporation, Inc.
6811 Kenilworth Avenue, Suite 306
Riverdale, MD 20737
Srinivasan Raghavan (301-927-3223)

Imagery gathered by the earth observation systems (EOS) places a heavy burden on computational resources. Retrieving and archiving massive image databases generated using EOS requires efficient and real-time algorithms. This project's approach to solving this problem is to use the object-oriented design theme. This theme allows image features, such as land cover, vegetation, and other important image characteristics, to be used as an index for the images in the database. To aid the process of feature extraction, Phase I will develop a synergic framework of neural networks and an expert system supported by fuzzy logic. Specifically, parallel algorithms will be developed in conjunction with this framework to achieve sensor fusion and feature extraction. The company will show a proof-of-concept demonstration of the parallel algorithms on a parallel machine, Zephyr (Wavetracer Inc.), that is available in-house.

Potential Commercial Applications: Applications include remote sensing for agricultural purposes, EOS data management, coastal feature extraction and habitat loss

analysis, weather understanding, and environmental monitoring.

***

126 LaRC
92-1-07.03-0230 NAS01-19888
Electro-Optical and Optical Nodes for Integrated Data Systems
Dove Electronics, Inc.
227 Liberty Plaza
Rome, NY 13440
John F. Dove (315-336-0230)

NASA and DoD have a documented need for data and signal processing and communication bandwidths which are far greater than today's system capability. The optical data and signal processing function came into prominence in the mid-to-late fifties with the development of the optical correlator and spectrum analyzer. One partial solution is to develop high-performance electro-optical and optical nodes. In Phase II, this project investigates 100 to 1000 gigabit/second optical nodes, and their implementation is tested in Phase II. The company is developing a waveguide holographic-pulse-distribution and combining technique that increases transmission data rate capability by order of magnitude.

Potential Commercial Applications: Electro-optical and optical nodes can be used by airline and hotel reservation networks, in closed-circuit digital television networks, educational networks, high-speed networks for the Fortune 500 companies' information exchange, state-wide optical networks, and high-speed computer networks.

***

127 LaRC
92-1-07.03-9411 NAS01-19908
Individually Addressable Array of Blue Laser Sources
Spectra Diode Laboratories, Inc.
80 Rose Orchard Way
San Jose, CA 95134-1356
R. Waarts (408-943-9411)

The goal of this project is to design, fabricate, test, and deliver an array of individually addressable, frequency-doubled laser diodes for optical data storage applications. The emission wavelength of the laser source is 415 nm at an output power of 10 mW per channel in a diffraction-limited beam. Phase I will investigate the critical components and Phase II will integrate the components into a two-channel, individually-addressed compact blue laser array. The array will not only be compact and efficient but also will be designed to be manufacturable within the requirements for optical data storage systems. The individually addressable laser source will increase data storage for the spaceflight optical disk recorder through a four-times smaller read-write spot on the optical disk. A compact blue laser source is also useful for other technologies such as commercial optical recording and color printing and is critical to U.S. competitiveness in these markets.

Potential Commercial Applications: Applications include optical data storage, printing, medical diagnostics, and displays.

***

128 JSC
92-1-07.04-8100 NAS09-18853
A Query System for Heterogeneous, Distributed Database Management Using a Massively Parallel Hyper-Index
Data Parallel Systems, Inc.
4617 East Morningside Drive
Bloomington, IN 47408
Latha S. Colby (812-334-8100)

Performance problems associated with accessing data that is distributed among various sites, computers, and relational database management systems are not amenable to purely software solutions. The relative performance of commercial databases on a variety of queries and hardware systems, the relative size and location of tables, and network bandwidth and loading are issues that must be addressed in order to balance loads and produce reasonable response times. These factors also increase the complexity of associated software. Even if all of these parameters can be taken into account, current database technologies do not provide the performance needed for such very large databases as those maintained by NASA sites. The company has developed the Hyper-Index Parallel Database Accelerator to accelerate query processing on single relational databases by up to three orders-of-magnitude, using the massive degree of parallelism of the MasPar MP-1 supercomputer and other proprietary storage structures and algorithms. The hyper-index is potentially a very powerful network management tool for distributed databases because it can, for many queries, use a limited amount of centralized data and indexes to produce fast results while reducing network traffic.

Potential Commercial Applications: A network-based, distributed database management system, one that delivers the query performance and the reduced network load offered by the hyper-index approach, is a product for which government and business will find many applications.

***

129 JPL
92-1-07.05-2577 NAS07-1234
Fractal and/or Wavelet Real-Time Image Compression
Fastman, Inc.
1414 Millard Street
Bethlehem, PA 18018
Michael Tucker (215-691-2577)

Higher data rates and increasingly complex and sophisticated spacecraft instruments tax the limited bandwidths available for transmission to the ground and make necessary onboard data reduction. The goal of this project is to develop a highly efficient, image compression algorithm which is adaptable to electronic still photography, video data compressions for satellite communications, and image compression for manned space systems.

Potential Commercial Applications: This data compression algorithm has significant commercial potential because it can operate in real-time. Digital-signal-processing-chip sets and circuit boards will be developed for sale and licensing to original equipment manufacturers in the telecommunications, medical and industrial imaging, and defense industries. Some initial applications include image compression for medical images, industrial images, multimedia, and teleconferencing.

***

130 GSFC
92-1-07.06-7978 NAS05-32400
The NetBook System
Advanced Applications Corporation
3 Woodsend Place
Potomac, MD 20854
Kimberly Huang (301-424-7978)

This project will develop a NetBook system that provides mechanisms for modeling, integrating, accessing, searching, and managing software, data, and bibliographic repositories in a manner that is transparent to the user. The approach is based on the object-oriented book paradigm and the client-server model to combine separately developed information resources into an integrated entity so that the user has a global uniform view of the information. With a simple protocol and a set of tools, the information can be retrieved, viewed, and easily managed across heterogeneous environments. Furthermore, as client applications and multiple servers are installed over the networks, the information resources will be distributed and shared. As a result, the NetBook will solve the complexity of the integration of heterogenous, distributed-information, repository management problems and fulfill a goal of the high-performance computing and communications program. Phase I will result in a prototype demonstration on a UNIX platform connected over the Internet network accessing all participating repositories. Phase II will be focused on a generic NetBook system that can be used on PCs, Macs, and other workstations.

Potential Commercial Applications: The methodology will facilitate the exchange of information across the heterogeneous distributed environment among enterprises. It is applicable to any application in which the storage and maintenance of heterogeneous object types is essential.

***

08: Instrumentation and Sensors

131 GSFC
92-1-08.01-1896 NAS05-32439
A High-Energy, Efficient, Diode-Pumped, Narrow Band, Tunable Laser for the Near-Infrared Wavelength
Science & Engineering Services, Inc.
4040 Blackburn Lane, Suite 105
Burtonsville, MD 20866
Hyo Sang Lee (301-989-1896)

Compact, high-efficiency, short pulse, high-energy lasers operating in the near infrared region are required for many of NASA's space-based sensors, such as laser altimeters for high resolution topographic mapping, and differential absorption lidars (DIAL) for profiling atmospheric temperature, pressure, and concentrations of molecular constituents. Efficient, tunable, Q-switched laser operation from 720 to 900 nm is possible with the new laser crystal Cr:LiCAF pumped by laser diodes arrays emitting in the 670 nm region. This project will develop a high-energy, 20 mJ/pulse, compact, efficient, tunable, Q-switched, diode-pumped Cr:LiCAF laser suitable for the above applications. The system will have several novel features, including a ring cavity incorporating the tuning element and an innovative side pumping geometry for coupling multiple, pump-diode bars to the laser rod. Injection seeding with a stabilized tunable InGaAs diode laser will achieve stable (0.0005 cm^{-1}), narrow band (0.001 cm^{-1}) single-mode operation. By combining the new, efficient laser material LiCAF (wall-plug efficiencies >20 percent) with the emerging technology of high-power diode lasers, the laser represents a major advancement of solid-state lasers. The inherent reliability of the laser will also satisfy the requirement for autonomous spaceborne operation.

Potential Commercial Applications: The laser can be easily modified for mode-locked operation, or its wavelength can be extended to a tuning range by frequency doubling. Many commercial applications are anticipated, such as portable DIAL lidars for monitoring pollutants and other species, high-resolution spectroscopy, photochemical reaction dynamics, hydrocarbon detection, petroleum exploration, and medical applications.

***

132 GSFC
92-1-08.01-2114 NAS05-32431
Q-Switched, Diode-Pumped, Microchip Laser Arrays for Laser Altimetry
Micracor, Inc.
696 Virginia Road
Concord, MA 01742
K.F. Wall (508-371-2114)

As part of laser altimeter systems, Q-switched, diode-pumped, solid-state lasers are desirable for producing high-resolution topographic measurements of earth, lunar, and planetary surfaces. Laser altimeter transmitters must be compact, lightweight, power efficient, reliable, and long-lasting. They also must be able to produce 20 mJ/pulse and to operate in wavelengths between 700 to 950 nm. Phase I will study the feasibility of producing a microchip laser array that meets laser altimetry requirements. Microchip laser arrays employ a single, monolithic laser medium that is pumped by an array of pump sources to produce an array of individual emitters. Microchip array technology represents an innovative approach to producing lasers because it employs a parallel architecture and very compact laser cavities. Microchip laser arrays are better than conventional laser technology because they are reliable, very bright, rugged, and compact.

Potential Commercial Applications: These laser arrays can be used in lidar, materials processing, medicine, spectroscopy, and blue light sources via frequency doubling.

***

133 GSFC
92-1-08.01-7671 NAS05-32421
Advanced, Diode-Pumped, Cavity-Dumped Laser for Space-Based Altimetry
Fibertek, Inc.
510 Herndon Parkway
Herndon, VA 22070
Alan Hays (703-471-7671)

This project will demonstrate the feasibility of a nanosecond, diode-pumped, cavity-dumped laser for application in space-based altimetry. Under this project, a diode-pumped laser testbed will be set up in order to test resonator cavity configuration and electro-optics switch materials. The performance of two different electro-optic materials, KD*P and KTP, will be evaluated in the testbed. Alternate solid-state laser materials for use in generating 0.7 to 0.95 μm output will be critically evaluated for use in the cavity-dumped laser, based on their optical, mechanical, and thermal properties. Phase I will establish the feasibility of developing a space-qualified, diode-pumped laser for NASA applications in space-based, high-resolution topographic mapping and atmospheric remote sensing.

Potential Commercial Applications: The nanosecond, diode-pumped laser will have commercial application as a pump laser for tunable dye and titanium-sapphire lasers. Commercial applications in aircraft-based topography and bathymetry, as well as precision ranging, are possible.

***

134 LaRC
92-1-08.02-8736 NAS01-19872
Using a Solid-State Coherent Lidar for Precision Inflight Measurement of Turbulent Air Motion
Coherent Technologies, Inc.
P.O. Box 7488
Boulder, CO 80306
Stephen M. Hannon (303-449-8736)

The objective of this project is to design an airborne, two-micron pulsed, coherent, solid-state lidar system that can measure time variations of the three-dimensional, atmospheric, turbulent velocity components with a precision of 0.05 meters/second or better. These measurements will be made at a point far enough from the aircraft (10 meters or greater) to avoid disturbance. Atmosphere aerosols or cloud droplets will provide the desired air motion tracers, while simple conical scan of the optical-system focal point, along a helical path traced out by the translation of the aircraft, will be used to infer the instantaneous wind vector along the flight path. Pulsing the laser provides high peak power and enables a much higher signal-to-noise-ratio per pulse at modest mean power. The speckle errors, which affect the velocity precision at high signal-to-noise-ratios, are reduced in a focused system because the illumination has a short depth of field. This project will determine design parameters using detailed lidar simulations and will conduct demonstration experiments using an existing 2 μm pulsed, focused, coherent lidar system.

Potential Commercial Applications: The principal application will be for optical air-data systems for commercial and military aircraft, particularly for on-board wind shear detection. The three-dimensional wind field measurement capability will be useful on research aircraft.

***

135 LaRC
92-1-08.03-6250 NAS01-19902
An Autonomous Lidar for Remote Monitoring of Polar Stratospheric Clouds
Research Support Instruments, Inc.
10610 Beaver Dam Road
Hunt Valley, MD 21030-2288
Jack A. McKay (410-785-6250)

Lidars can observe the structure and formation dynamics of polar stratospheric clouds (PSCs) which play a critical role in ozone depletion. Fielding conventional lidars in remote polar regions is expensive, manpower-intensive work that must be confined to limited-duration research campaigns at only a few

scientific sites. This project will design (Phase I) and build (Phase II) a highly reliable, low maintenance, autonomously operable, eye-safe lidar suitable for fielding at remote, harsh-environment sites. Because building and operating the lidar will be relatively inexpensive, the equipment can be used at many locations. While the combination of high reliability, low maintenance needs, stratospheric measurement capability, and absolute eye-safety is not currently available in existing lidars, a successful Phase I design will encourage the development of a network of stratospheric lidars, providing inexpensive geographical coverage of PSC formation and dissipation throughout the polar night and into the polar spring.

Potential Commercial Applications: Potential commercial applications include eye safe, autonomous, tropospheric lidars for weather monitoring in remote areas and visibility monitoring near airports. Eye safety and low maintenance is especially important for pollutant monitoring from such particulate emitters as power plants in urban areas. Another application is the monitoring of cloud cover in remote locations for atmospheric energy balance data.

***

136 GSFC
92-1-08.04-7001 NAS05-32441
Quantum-Well Cloud Sensor
Space Instruments, Inc.
4403 Manchester Avenue, Suite 203
Encinitas, CA 92024
James W. Hoffman (619-944-7001)

The radiation characteristics of clouds are important factors in understanding the Earth's climate. Cloud properties in the infrared region have not previously been well measured from space. The quantum-well cloud sensor (QCS) is an innovative spaceborne instrument for imaging clouds and measuring their thermal brightness and bi-directional reflectance in selected long wavelength spectral bands. It also provides stereo viewing of clouds for altitude measurements. The QCS utilizes a GaAs, quantum-well, infrared photodetector (QUIP) array. This detector array has extremely good pixel-to-pixel uniformity and negligible i/f noise, which is important for future geostationary sensors that will use long signal integration times to compensate for their narrow field of views. In contrast to doped-silicon and HgCdTe arrays which are expensive, difficult to produce, and low yielding, the QUIP arrays promise to be more easily and uniformly producible and significantly less expensive. The anticipated results of Phase I are a feasibility analysis and a conceptual design for a complete instrument which could be built in Phase II and flown on a get-away special on the shuttle.

Potential Commercial Applications: Due to the lower manufacturing cost and negligible i/f noise of the QUIP detector array, the quantum-well cloud sensor is intended to be the forerunner of a line of commercial mid- and long-wavelength sensors.

***

137 GSFC
92-1-08.04-8442 NAS05-32409
Measurement of Solar Radiation Variations as an Influence on Climate
Applied Research Corporation
8201 Corporate Drive, Suite 1120
Landover, MD 20785
Andrew Endal (301-459-8442)

The solar disk sextant (SDS) is a spaceborne instrument for precise measurement of the apparent solar diameter. These measurements, with simultaneous measurements of the solar irradiance, will calibrate the historical record of solar diameter measurements to determine whether changes in the total solar radiation at the top of the atmosphere have contributed to climate change. A critical component of the SDS instrument is the beam-splitting wedge (BSW) that provides the reference angle for measurement of the solar diameter. This project will develop and evaluate several BSW designs to determine which can be used in a long-duration space environment. Specifically, this project will evaluate molecular bonding of the BSW optical components to provide a stable wedge angle; a double-wedge design to correct for chromatic aberration; fabrication processes for the wedge filter; interferometric methods for pre-flight calibration of the wedge angle; and on-orbit wedge calibration procedures using the orbital variations in the Sun-to-SDS distance. The SDS has been selected as a joint NASA/Italian Space Agency experiment to complement other NASA climate programs such as the precipitation and radiation measurements to be provided by the Tropical Rainfall Measurement Mission.

Potential Commercial Applications: The effort will expand the firm's capabilities for providing specialized space hardware subsystems. The potential for penetrating the European market is particularly important in terms of U.S. participation in this rapidly expanding area.

***

138 LaRC
92-1-08.05-0060 NAS01-19881
Synthesis and Crystal Growth of New Nonlinear Optical Materials in the System $KTiOPO_4$-$CsTiOPO_4$
Crystal Association, Inc.
15 Industrial Park
Waldwick, NJ 07463
G. M. Loiacono (201-612-0060)

This project will test whether tailoring the refractive index ellipsoid of potassium-titanyl-phosphate (KTP) will permit Type II phase matching at wavelengths shorter

than 900 nm. If this procedure is possible, it will permit the second harmonic generation (SHG) of laser diodes and Ti:Al_2O_3 solid-state lasers. The system of solid solutions derived from mixing KTP with $CsTiOPO_4$ will be studied, and the crystals for evaluation grown. The nonlinear optical, mechanical, and electrical properties of these crystals will be determined, and the data will be compared with pure KTP.

Potential Commercial Applications: The benefits of this project will be the identification of a new, nonlinear optical material suitable for SHG of laser diodes and solid state lasers operating in the wave-length range of less than 900 nm. Commercial-size crystals of quality refinement will then be grown to permit a domestic source of large, inexpensive nonlinear crystals for military and commercial applications.

***

139 LaRC
92-1-08.05-3772 NAS01-19903
An Improved 2.0/2.1 Micron Laser
Scientific Materials Corporation
310 Icepond Road
Bozeman, MT 59715
Ralph L. Hutcheson (406-585-3772)

Two variables have been discovered by the firm in the structure of CTH:YAG (Chromium, Thulium, Holmium:yttrium, aluminum, garnet). These variables, which influence lasers by as much as 40 percent, relate to the internal chemistry of the crystal and are believed to be significant factors related to the performance and damage in all solid-state lasers. This project will quantify these variables to establish tolerances and relate these quantified values to laser performance. Phase II will deliver to NASA improved hardware based on these improved materials.

Potential Commercial Applications: Applications include medical lasers and optical parametric oscillators.

***

140 LaRC
92-1-08.05-9411A NAS01-19905
High-Power, Visible, Semiconductor Laser Diodes for Solid-State Laser Pumping
Spectra Diode Laboratories, Inc.
80 Rose Orchard Way
San Jose, CA 95134-1356
Randall S. Geels (408-943-9411)

The company will develop a high power, AlGaInP-based, five-bar stack of diode lasers emitting at 660 to 680 nm at a reliable output power of 250 W quasi-continuous wave (QCW) for pumping tunable Cr:$LiSrAlF_6$ and Cr:$LiCaAlF_6$ lasers. These Cr-doped materials address NASA's need for tunable solid-state lasers emitting at 0.7 to 1.1 μm. Development of diode pumps for these materials represents a significant advancement in the technology. Recently, the firm has pioneered high-powered visible lasers with output powers greater than 10 W CW and 60 W QCW; however, the reliability at 20 W QCW has not been developed beyond 10^5 pulses. The project will further advance the characteristics of AlGaInP lasers to achieve high-powered reliable operation. Phase I will study a one-bar laser with a goal output power of 50 W QCW and a goal lifetime exceeding 10^7 pulses. Phase II will build on this technology to demonstrate a five-bar stack emitting 250 W QCW with a lifetime 10^9 pulses.

Potential Commercial Applications: Potential commercial applications include atmospheric sensing of gases and aerosols, spectroscopy, and Ti:Sapphire laser replacement. Applications of the laser diodes alone include photodynamic therapy, color display systems, and illumination systems. The technology will also foster advancements in printing and optical data storage.

***

141 MSFC
92-1-08.06-3088 NAS08-39837
A Spectroscopic Imaging Sensor Using Parallel Pixel Filtering
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Shudong Wu (310-320-3088)

This project will develop a novel spectral separation technique, parallel pixel filtering (PPF), for two-dimensional imaging with high spectral, spatial, and temporal resolution. The technique uses a pixel filter array at the focal plane to enable an imaging system to reject light from all out-of-focus planes and to demonstrate high-depth discrimination. By using a highly dispersive, diffractive imaging element, images at different wavelengths are axially separated. Consequently, only the image at the in-focus-wavelength can pass through the pixel filter array, and two-dimensional images with narrow spectral widths can be obtained. This project pioneers the use of three-dimensional spatial filtering to perform the spectral separation. The instrument will be compact, rugged, and lightweight and may lead to the development of a new generation of spectroscopic imaging sensors.

Potential Commercial Applications: The PPF technique can be used for three-dimensional microscopic imaging in biomedicine, opthamology, and microelectronics.

***

142 MSFC
92-1-08.06-6000 NAS08-39826
Thermally Stable, Large-Aperture, High-Resolution Optics
Composite Optics, Inc.
9617 Distribution Avenue
San Diego, CA 92121
Eric N. Thorstenson (619-586-6000)

Empirical data will be generated to support analysis modeling assumptions. This project will explore core design, facesheet laminate design, and varlous assembly techniques, and the latest in mold and replication technology will be attempted.

Potential Commercial Applications: These lightweight, large, stable optics can be used for airplane and satellite sensors.

***

143 MSFC
92-1-08.06-7990 NAS08-39806
Diffractive Optics Technology for Earth Observing Instruments in Geostationary Orbit
Rochester Photonics Corporation
80 O'Connor Road
Fairport, NY 14450
Dean Faklis (716-377-7990)

Diffractive (or binary) optics may provide a key technology for the development of lightweight, high-performance optical systems for space applications. In particular, diffractive optics technology may make significant improvements in several of the instruments that are being planned for the Geostationary Earth Observatory (GEO). Phase I will investigate the following topics: the design of an all-diffractive, narrowband telescope for the lightning mapper sensor (LMS); the design of diffractive-refractive hybrid lenses for application in the aft-optical systems, such as the GeoPlatform High-Resolution Interferometer Sounder (GPHIS) and the NOAA GOES N multi-spectral imager; and the use of diffractive elements to athermalize infrared optical systems. Using computer ray-traced methods, this project will characterize the imaging properties of the optical systems. In addition, the fabrication processes that can be used to manufacture the diffractive elements will be specified, and a cost analysis for a prototype optical system will be provided. Phase II will be devoted to fabricating a prototype diffractive optics system for an instrument slated for geostationary observations.

Potential Commercial Applications: This work will benefit space, military, and commercial applications that require lightweight, high performance optical systems. System applications include lidar systems for atmospheric and pollution monitoring; coherent communications; and narrowband and broadband imaging systems for the ultraviolet, visible and infrared wavelength regions.

***

144 MSFC
92-1-08.06-8211 NAS08-39845
Earth Observing Sensor Development for Geostationary Orbit
Irvine Sensors Corporation
3001 Redhill Avenue, Building 3, Suite 208
Costa Mesa, CA 92626
Chris H. Saunders (714-549-8211)

An advanced integrated circuit (IC) will be developed to read out high-density visible and infrared detector arrays for earth observation from geostationary orbit. The IC will contain a low-noise preamplifier that uses Bi-CMOS technology and a high degree of on-chip signal processing functionality, including preamplification, temporal filtering, digital-pulse-amplitude readout, and digital-pulse-width readout. The project will design the IC to be compatible with the HYMOSS Z-plane architecture to provide functional modules with the resolution capability of 220 x 220 pixels on 60 micron centers. The desired noise level is 100 electrons in an integration bandwidth of 500 Hz.

Potential Commercial Applications: A focal plane composed of these modules would be ideal for applications such as lightning detection. The IC can be used in low-power neurological sensing.

***

145 ARC
92-1-08.07-0003 NAS02-13812
A Disposable Optical Ozonesonde for Airborne Stratospheric and Tropospheric Ozone Measurements by Small Balloons
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
W.T. Rawlins (508-689-0003)

A laboratory pre-prototype of an optical ozonesonde will be designed, built, and tested for disposable, balloon-borne sounding of the stratosphere and troposphere. The device will use short-path UV absorption and high-precision signal processing circuitry to enable high-sensitivity, absolute determinations of ozone concentrations from the ground to 40 km. The laboratory tests will evaluate the instrument sensitivity, thermal stability, and operating characteristics upon exposure to low pressures and temperatures. The end result of Phase I will be a working design of prototype flight instruments to be built and flown in Phase II. The eventual flight instrument will be superior to current disposable sonde technology because it will be much easier to implement in the field, will provide higher altitude coverage for satellite validation, and will provide accurate absolute ozone determinations without the

need for ground-based corroborations. The instrument can be used reliably at any accessible location, and will provide previously unavailable sounding capabilities for determinations of ozone depletion in the high-latitude polar winter.

Potential Commercial Applications: The optical ozonesonde has commercial applications for worldwide atmospheric monitoring networks for tropospheric ozone and climatology research.

***

146 ARC
92-1-08.07-3088 NAS02-13787
Fiber-Optic Sensor for Low-Level Humidity Measurement in the Upper Atmosphere
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Edward Schmidlin (310-320-3088)

This project will examine using porous silica optrodes to sense upper atmospheric water vapor. The sensor head is a cylinder made of porous glass positioned between two non-imaging optic (NIO) elements. Light is passed through the sensor head, and the intensity of transmitted light is measured with a detector. A filter is used to select the wavelength of light that demonstrates the greatest change in optical transmission. Using the new NIO elements will increase the sensor head volume over that of demonstrated porous silica sensors and will lead to sensitivities at ppm levels. Commercially available hygrometers (frost-point and Lyman-alpha) for upper atmospheric humidity measurement are expensive, heavy, and require routine maintenance. Because the humidity sensor is based on fiber optics, it has the advantages of being compact, lightweight, and potentially low in cost. During Phase I, a proof-of-concept sensor will be constructed and tested in an atmosphere simulation test chamber.

Potential Commercial Applications: Since porous fiber humidity sensors have a wide dynamic range, 0-80 percent relative humidity, and potential for very high sensitivity, they could be used for enclosed plant growth chambers, combustion monitoring, and humidity measurements in ovens heated to 500°C.

***

147 ARC
92-1-08.07-9500 NAS02-13772
Open-Path IR Absorption for Airborne Measurements of Stratospheric Trace Gases
Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
Mark S. Zahniser (508-663-9500)

Infrared absorption, using tunable diode lasers from aircraft and balloon platforms measures stratospheric trace gas. The goal of this project is to develop a new open-path absorption cell suitable for in situ measurements of reactive trace species from an aircraft platform. The open-path design, in which the laser beam undergoes multiple reflections between two mirrors located on the wing and the fuselage, is preferable to more commonly used enclosed path sampling cells because reactive gases may be perturbed by sampling inlets and surfaces. This project will test a multipass cell that uses a novel astigmatic mirror system which can obtain sufficient path length (600 m) with relatively small diameter mirrors (~10 cm). This cell will minimize size, weight, and aerodynamic perturbations and will make the system particularly suitable for deployment on small, unmanned aircraft being developed for stratospheric research. Phase I research would optimize the design of the mirrors, develop an automated alignment method, and evaluate the applicability of the open-path absorption system for detecting target stratospheric trace gases such as HNO_3, HOCl, HCl, $ClONO_2$, and the HO_2 radical.

Potential Commercial Applications: The astigmatic mirror system would be useful in assessing stratospheric ozone depletion and in monitoring atmospheric trace gas from aircraft or balloon platforms. The long path, low-volume cell would also be useful in laboratory and industrial applications requiring high sensitivity, small sample size, or rapid time response when using optical or infrared absorption techniques.

***

148 JPL
92-1-08.08-4068 NAS07-1206
Construction of a Liquid-Crystal Tunable Filter for Visible Light
Meadowlark Optics, Inc.
7460 Weld County, Road 1
Longmont, CO 80504-9470
Thomas G. Baur (303-776-4068)

This project will demonstrate a prototype liquid crystal tunable filter for use in remote sensing. It will be a hybrid Solc Lyot filter for maximum transmission, and it will use standard, nematic liquid-crystal variable retarders as wavelength tuning elements. Most of the fixed, multiwave retarders will be made using low-cost birefringent polymers similar to the firm's standard product. The filter will have a passband width of about 6 nm, and it will be wavelength tunable from 400 nm to 750 nm. While the package is small and lightweight, requiring only low power and low voltage for tuning, it will have a wide angular field of view of ±14°, a clear aperture of 30 mm, and a tuning time of 4 to 5 milliseconds. The firm will manufacture all optical components and will characterize the filter performance. The firm will also supply an electronic controller for tuning the filter.

Potential Commercial Applications: The filter will have commercial applications wherever imaging spectro-

photometry is useful, for example, in paint color analysis, video display color analysis, solar physics, submarine communications, and fiber optics communications.

***

149 JPL
92-1-08.08-8958 NAS07-1229
Ferroelectric, Liquid-Crystal, Tunable Optical Fibers
Boulder Nonlinear Systems, Inc.
1898 South Flatiron Court
Boulder, CO 80301
Gary Sharp (303-786-8958)

Liquid crystals offer an attractive method for electronically tuning optical filters. Nematic liquid-crystal, tunable filters, based on polarization interference and absolute phase interference (Fabry-Perot etalons), have been successfully demonstrated in UV through IR wavelengths. However, due to their slow tuning speeds, they offer little improvement over mechanical methods for tuning optical filters. Ferroelectric liquid crystals (FLCs) have been used recently to tune, both discretely and continuously, polarization interference filters and have shown potential for tuning Fabry-Perot filters with a 10^4 increase in tuning speed over nematic materials. This project applies an approach developed at the firm for optimal tuning of birefringent filters as well as for a completely novel method for tuning Fabry-Perot filters. The project's goal is to develop continuously tunable filters using FLC materials for operation in the visible and near-infrared wavelength bands. All techniques for tuning optical filters will be considered in Phase I research.

Potential Commercial Applications: An FLC optical filter has benefits over nematic filters for all applications where rapid tuning is required. Because progress in FLC tunable frequency design indicates that broad, continuous tunability is easily achieved, enormous potential exits for its use in broadband remote sensing applications.

***

150 JPL
92-1-08.09-1190 NAS07-1219
High-Resolution, Ultra-Low Power, Superconducting, Analog-to-Digital Converter
Hypres, Inc.
175 Clearbrook Road
Elmsford, NY 10523
Sergey Rylov (914-592-1190)

A low-power, high-performance, superconducting, analog-to-digital converter (ADC) will be developed. This ADC is based on principles of counting single magnetic flux quanta and high-speed differential coding. The ADC will have wide bandwidth and high accuracy in operation. Implemented in 1-micron design rules, this ADC is expected to have 16 effective bits at a sampling rate of 1 MS/s (500 kHz bandwidth) and a sensitivity better than 1 μA/LSB. If equipped with an on-chip decimation filter, the ultimate performance is calculated to be 17.1 effective bits at 50 MHz bandwidth with an internal sampling at 100 GS/s. This performance cannot be achieved with any other technology. More importantly, the superconducting ADC power dissipation is three orders of magnitude lower than semiconducting ADCs, typically 1 to 3 mW in an area smaller than 1 cm^2. The counter-type ADC requires a flux quantizer feeding into multi-bit counters and a timed readout circuit. The firm has already demonstrated full operation of the flux quantizer and of the counters. Phase I will design, fabricate (using the company's niobium technology), and demonstrate the necessary timing circuit (synchronizer) connected to short (4-bit) counters based on novel designs utilizing rapid, single-flux quantum circuits. This demonstration, coupled with the results already achieved for the remaining ADC components, will establish for the first time the complete feasibility of a practical flux-counting ADC. A fully operational 16-bit ADC will be demonstrated in Phase II through signal reconstruction for frequencies exceeding 50 kHz and with power dissipation less than 3 mW. These ADCs have an immediate application in the readout circuits of focal plane sensor arrays being developed for NASA missions.

Potential Commercial Applications: There are numerous commercial applications for this type of A-D converters including precision electronic instrumentation, digital RF equipment, and biomedical imaging arrays.

***

151 GSFC
92-1-08 10-0774 NAS05-32438
Back-Illuminated, Charge-Coupled-Device Image Sensor
Princeton Scientific Instruments, Inc.
40 Autumn Hill Road
Monmourh Junction, NJ 08852
John L. Lowrance (908-274-0774)

This project will develop a back-illuminated image sensor based on charge-coupled-device (CCD) technology with improved stable quantum efficiency in the ultraviolet as well as the visible spectrum. The CCD will also have high quantum efficiency in the soft x-ray region and be useful in electron bombarded applications. The high quantum efficiency that can be attained with this back-illuminated CCD, combined with the very low readout noise at wide bandwidth, makes it possible for this CCD to replace image intensifier-CCD image sensors currently used for night vision and low light surveillance applications. Unlike other cameras, the CCD sensor is small and reliable, has a longer life and broader spectral response, and, therefore, has significant commercial and NASA applications.

Potential Commercial Applications: The CCD image sensor can be used in NASA astronomical missions,

ground-based scientific imaging instruments, and for low-light surveillance cameras in law enforcement and industrial applications.

***

152 GSFC
92-1-08.10-1100 NAS05-32404
Silicon-Carbide, High-Resolution, Room-Temperature X-Ray Detector
Advanced Technology Materials, Inc.
7 Commerce Drive
Danbury, CT 06810
Bo Yang Lin (203-794-1100)

A semiconductor's usefulness as a high-resolution, room-temperature radiation detector is dictated primarily by the requirement for small leakage currents. Most work in this area has been focused on silicon diodes which have achieved significant advances in recent years. Wide-bandgap semiconductors have inherently low leakage currents but have so far been overlooked because of their relatively early development stage. Recent advances in the fabrication of 6H-silicon-carbide (SiC) devices have changed this situation since diodes with extremely low leakage currents have been made and characterized. 6H-SiC detectors should have significantly higher resolution at or near room temperature than their silicon counterparts. Furthermore, 6H-SiC has excellent stability in severe physical and chemical environments, and is more resistant to radiation damage than silicon. This project will examine the use of SiC diodes as sub-keV x-ray detectors at or near room temperature. The feasibility of this concept will be demonstrated in Phase I, while Phase II will focus on device optimization and testing in conjunction with NASA.

Potential Commercial Applications: The ability to produce high-resolution, room-temperature x-ray detectors will lay the groundwork for a broad spectrum of commercial detectors including ultra-violet, particle, and other types of detectors where radiation-hardness and room-temperature operation are required.

***

153 GSFC
92-1-08.10-1190 NAS05-32424
Wide-Dynamic-Range, Digital, Superconducting Quantum Interference Device Amplifiers for Multiplexing and Readout of Cryogenic Detector Arrays
Hypres, Inc.
175 Clearbrook Road
Elmsford, NY 10523
Masoud Radparvar (914-592-1190)

Superconducting quantum interference devices (SQUIDs) are extremely sensitive detectors of magnetic flux and can be used as low noise amplifiers for cryogenic detectors. In order to use a SQUID as an amplifier, its transfer characteristics should be linearized. This linearization, however, requires extensive peripheral electronics, thus limiting the number of SQUID channels in a practical system. The digital SQUID integrates the processing circuitry on the same cryogenic chip as the SQUID amplifier and eliminates the sophisticated peripheral electronics. Such a system will be compact, cost effective, and require minimal electronic support. This project will lead to the development of all-thin-film digital SQUID chips. Each chip, in addition to having on-chip processing circuitry coupled to a SQUID, will also have an integrated superconducting transformer to facilitate its interface to an external multiplexer coupled to a cryogenic detector. As a result of this effort, it will be possible to design and fabricate single chips that will contain arrays of digital SQUIDs for integration in a multi-channel SQUID system, thereby reducing the cost and complexity of such systems. Due to the company's recent progress in superconducting electronics, the design, fabrication, and evaluation of digital SQUID chips will be conducted under Phase I.

Potential Commercial Applications: This project will lead to the development of all-thin film SQUID chips as ultra-low noise amplifiers. The chip is a self-contained digital SQUID amplifier with on-chip processing circuits and will require minimal support electronics. Consequently, arrays of such chips are cost-effective for integration in cryogenic detector array systems.

***

154 GSFC
92-1-08.10-1859 NAS05-32426
A New Approach to Silicon X-Ray Spectrometers
Intraspec, Inc.
P.O. Box 4579
Oak Ridge, TN 37831-4579
John Walter (615-483-1859)

This project identifies a new approach to silicon x-ray detector technology. This technology involves changing the detector geometry to provide much lower capacitance for a given active area and volume; replacing the Si(Li) detector with a stable oxide-passivated, low leakage-current, high-resistivity Si element, and the conventional field effect transistor in the preamplifier with an onboard ASIC preamplifier having improved high-frequency noise. The low capacitance and lower preamplifier noise will allow operation at higher frequencies, thereby further reducing the peak broadening from detector leakage current noise. In addition to making a major change in the noise at or near room temperature, this approach will allow faster counting rates. Because it is compatible with hermetic encapsulation, this approach will provide an environmentally stable detector-preamplifier package that should have sub-keV x-ray energy resolution at or near room temperature and improved characteristics, including larger active areas and better count rate capability, at low temperatures.

Potential Commercial Applications: Current Si x-ray spectrometers require cooling of the detector with liquid nitrogen, which is an expensive and sometimes logistically impractical process. Replacement of Si(Li) technology with a temperature-stable, low-capacitance, Si substrate, which has low-leakage current at room temperature, and an improved preamplifier, will have a major impact on this important market.

***

155 GSFC
92-1-08.10-4759 NAS05-32440
Intensified Imager for Detection of Ultraviolet and Particles
Siegmund Scientific
2970 Honeysuckle Circle
Antioch, CA 94509
J.V. Vallerga (510-754-4759)

The detector concept consists of a windowless, microchannel plate image intensifier viewed by a charged-coupled-device (CCD) camera that detects and images ultraviolet (UV) radiation and particles. This project will take advantage of recent improvements in photocathode, microchannel plate, phosphor and fiber-optic technologies, as well as current CCD technology and optimized detector configurations. Image processing algorithms and fast signal processors will provide analog and/or photon counting imaging modes. This project will show that the optimized detector schemes can provide high spatial resolution (40 line pairs/mm analog, 10 μm photon counting), high quantum efficiency (greater than 50 percent on average), large counting rates (10^{10} photons/sec analog, greater than 5 x 10^4 events/sec photon counting) and high dynamic range with low background, small and large formats, and solar blindness.

Potential Commercial Applications: It is anticipated that the detector will find applications in future rocket, shuttle, and satellite instruments, for high performance imaging and spectroscopy in astrophysics, aeronomy, and solar and planetary physics. Specifically, the detector can be used in high-resolution UV spectroscopy, high-resolution mass spectroscopy, biological sample imaging, microscopy, and crystallography.

***

156 GSFC
92-1-08.10-6700 NAS05-32412
High-Temperature Superconductor, Yttria-Stabilized, Zirconia Membrane Bolometer
Conductus, Inc.
969 West Maude Avenue
Sunnyvale, CA 94086
Vincent Kotsubo (408-737-6700)

An array-compatible bolometer for operation at 90 K will be developed for use at long wavelengths and very long wavelengths of infrared radiation. The device will consist of a YBCO high-temperature-superconducting thin film as a temperature sensor, and an yttria-stabilized, zirconia membrane as the supporting structure. The use of the membrane is innovative because it has low heat capacity and thermal conductivity, which should provide a noise-equivalent power of 4.6 x 10^{-12} $W/Hz^{1/2}$, a factor of 4 improvement over the best existing bolometer technology of 1.88 x 10^{-11} $W/Hz^{1/2}$. Because microfabrication and photolithographic techniques will be used, this bolometer will be compatible with array fabrication. NASA will use the new infrared sensor technologies in the 65-90 K temperature range during long-life missions where the use of liquid helium is not practical.

Potential Commercial Applications: University, government, and commercial laboratories will use these bolometers in commercial infrared spectrometers for chemical analysis.

***

157 GSFC
92-1-08.10-8278A NAS05-32420
Infrared-Transmissive, Diamond-Like Carbon Films for Protecting High-Temperature Superconducting Detectors
Excel Superconductors, Inc.
140-29 Keyland Court
Bohemia, NY 11716
L. Ganapathi (516-563-8278)

High-temperature superconducting detectors have a unique place in sensor technology because they can operate over a broad range of wavelengths from infrared to beyond microwaves. They can be used as bolometers as well as quantum detectors. Their use, however, will be determined by their resistance to damage from numerous degrading agents in a typical working environment. Therefore, protecting the superconducting elements in these instruments with passivating techniques is necessary. This project will develop a process that will form a composite thin-film structure by depositing infrared-transmissive, hard, diamond-like carbon (DLC) film as a protective top layer over a high-temperature superconducting thin film. The room-temperature-deposited DLC film should not alter the composition of the underlying superconductor while it provides an excellent, hard, hermetic, conformal coverage. The protective layer will be deposited by a laser-plasma hybrid technique which produces hard, chemically resistant, hydrogen-free, DLC films at room temperature. The deposited films will be evaluated by various surface techniques to probe the surface as well as the interface of the films, and pH measurements will be applied to evaluate inertness of the surface to ambient moisture. Phase I will concentrate on depositing and characterizing these films and optimizing the deposition parameters to obtain the desired characteristics. Using several samples, the firm will evaluate how the protective coverage affects the superconducting properties of the underlying film and the mechanical

stability of the protective layer and the interface, especially during the cooldown and warmup cycles typical of their usage. Phase II will fabricate and characterize a robust YBCO detector with a protective coating of DLC film.

Potential Commercial Applications: This project may result in thick and thin, high-temperature superconducting films with long shelf life and no need for special storage procedures. Encapsulated devices may also be made from superconducting thin films.

***

158 GSFC
92-1-08.10-9090A NAS05-32418
Low-Temperature Fabrication of Barium-Strontium-Titania Films for Room-Temperature Infrared Detectors
EMCORE Corporation
35 Elizabeth Avenue
Somerset, NJ 08873
Chyi S. Chern (908-271-9090)

Highly oriented or epitaxial $Ba_{1-x}Sr_xTiO_3$ thin films on substrates are necessary for dielectric bolometers used in room-temperature, infrared (IR) detectors. $Ba_{1-x}Sr_xTiO_3$, due to its good dielectric properties and composition dependent curie temperature in the vicinity of room temperature, is an ideal material for high-performance dielectric bolometers. Making multilayered structures for IR sensing devices is difficult; therefore, the low-temperature, plasma-enhanced, metal-organic, chemical vapor deposition process, which incorporates a 1.5 KW microwave cavity generating an activated oxidizer, will be used to enhance the growth of epitaxial or highly oriented $Ba_{1-x}Sr_xTiO_3$ thin films on diamond and other technologically important substrates.

Potential Commercial Applications: This project will lead to large-scale fabrication of high-dielectric-constant material with curie temperature close to room temperature. This material will both promote IR sensing technology and provide dynamic random access memory technology for the computer manufacturing industry.

***

159 JPL
92-1-08.11-0610 NAS07-1232
An Infrared Focal Plane Array with User-Selectable Spectral Response
Sensors Unlimited, Inc.
3490 U.S. Route 1
Princeton, NJ 08540
Gregory H. Olsen (609-520-0610)

A novel focal plane array will be developed where the spectral response and noise properties of the array can be selected externally by the user. This project will produce a epitaxial wafer that has layers with longer wavelength response which are successively grown and then selectively removed so that the p-n junctions are formed in regions with different wavelength response (i.e. different bandgap or material composition). Phase I will use epitaxial layers of InGaAs/InAsP to make a linear detector array with cutoff wavelengths of 1.7, 2.2, and 2.7 μm at room temperature. Phase II will employ InGaAsSb alloys to extend these concepts out past 5.5 μm with 128 x 128 element focal plane arrays. Both room-temperature and thermo-electrically cooled device performance will be tested. The project will also demonstrate schemes for electronic and optical addressing of various pixel regions, as well as alternate configurations of the epitaxial layers.

Potential Commercial Applications: A focal plane array for novel imaging applications in the 0.9 to 5.5 μm spectrum will allow images formed by different wavelengths but by the same camera to be compared through the electronic selection of pixels. The response could also be expanded to the visible and ultraviolet region.

***

160 ARC
92-1-08.11-1548 NAS02-13771
Beamsplitters for Far Infrared to Millimeter Wavelengths
Nemo Filters
740 G Sierra Vista
Mountain View, CA 94043
Verne R. Costich (415-962-1548)

The development of beamsplitters having high efficiency, improved signal-to-noise ratio, and increased bandwidth is the goal of this project. This project will make both a prototype beamsplitter operating from 40 to 1000 microns and a beamsplitter operating from 160 to 4000 microns. It is anticipated that an increase of 200 to 800 percent increase will be made in the value of reflection time transmission. Other projected benefits include improved anti-reflection coatings and more efficient beamsplitters throughout the submillimeter region, faster data collection, and fewer splices needed between data sets. These beamsplitters will be used in fast-Fourier, Michelson interferometers, and other broadband submillimeter equipment which support ground-based astronomy and satellite experiments.

Potential Commercial Applications: Commercial applications include far-infrared and submillimeter wavelength beamsplitters, interferometer beamsplitters, and broadband and antireflection coatings.

***

161 JPL
92-1-08.11-6700 NAS07-1227
Inductive Sensing for a Superconducting Membrane Bolometer at 90 Kelvin
Conductus, Inc.
969 West Maude Avenue
Sunnyvale, CA 94086
Vincent Kotsubo (408-737-6705)

A bolometer will be developed that uses a non-contacting, inductive method for sensing the superconducting transition in a high-temperature-superconductor thin film. The bolometer will be designed for wavelengths longer than 20 microns where HgCdTe loses sensitivity and will be operated near 90 K. The change in mutual inductance of a sense coil in close proximity to a superconducting film will be detected as the film goes through the superconducting transition. This method will improve performance over the conventional method of measuring resistance because it avoids the use of current leads to decrease thermal conductance and increase sensitivity, and alleviates the problems of optimizing current-biased superconducting bolometers, such as self-heating, excess noise at high-bias levels, and impedance matching to amplifiers. Cooled infrared sensors in the low and very-low wavelength infrared range are needed that can outperform current room-temperature sensors, particularly since long-life mechanical coolers can now make feasible 5 to 10 year missions with focal-plane temperatures in the 65 to 90 K range.

Potential Commercial Applications: These bolometers will be used in commercial infrared spectrometers and will have improved sensitivity over existing room temperature sensors. The spectrometers are widely used for chemical analysis in university, government, and commercial laboratories.

***

162 JPL
92-1-08.12-4538 NAS07-1213
A Compact, Space-Qualified, 2.5 THz Local Oscillator for the Study of Ozone Chemistry
Innovative Research & Technology
843 Yale Street
Santa Monica, CA 90403
W. A. Peebles (310-828-4538)

The terahertz spectral region remains one of the last frontiers of the electromagnetic spectrum. NASA is developing radiometers for investigation of the Earth's upper atmosphere. In particular, there is currently great interest in monitoring the stratospheric ozone chemistry so that the destruction of the ozone layer and the accumulation of greenhouse gases associated with global warming can be understood. Space missions will utilize submillimeter-wave radiometers via the microwave, limb-sounding technique to probe various constituents related to ozone chemistry. However, difficulties associated with local oscillator availability for space missions has restricted the choice of radiometers to frequencies below ~700 GHz. A local oscillator source at ~2.51 THz would allow the crucial role of the OH radical to be directly monitored. The optically-pumped methanol FIR laser operates at this frequency. However, existing commercial lasers are bulky, inefficient, and incapable of space-flight. The primary goal of this project is to revolutionize this technology area and to develop an efficient, compact, integrated CO_2-FIR 2.5 THz laser system capable of space qualification and low loss operation with output powers ≥5 mW. Careful mechanical and rf design will limit prime power requirements to ≤75 W and provide an entire package with a volume about 0.5 m^3. Phase I will establish the feasibility of the innovation and generate preliminary designs. Phase II will design, fabricate, and test a 2.5 THz FIR laser system suitable for spaceborne missions.

Potential Commercial Applications: A successful completion of the Phase II project would generate a variety of research and commercial applications. For example, compact, moderate power, turn-key, submillimeter-wave sources are required in the diagnosis of magnetic confinement fusion plasmas, in non-destructive testing, and for molecular spectroscopy research.

***

163 ARC
92-1-08.13-1330 NAS02-13815
In Situ Particle Size Measurement Instrument for Aerosols in Microgravity
Insitec, Inc.
2110 Omega Road, Suite D
San Ramon, CA 94583
Donald J. Holve (510-837-1330)

This project will develop an instrument for in situ measurement of particle-size-distribution for non-intrusive measurements of aerosols inside an environmentally controlled, microgravity chamber for the size range of 0.01 to 1000 microns. This real-time, remotely operated instrument uses optical light scattering methods to measure conditions appropriate to a variety of ground and flight-based research experiments of interest to NASA. This project will address the application requirements of both microgravity and ground-based experiments for the study of aerosol growth in low pressure environments which simulate extraterrestrial environments. Phase I work will perform preliminary experiments with a modified, in situ, light scattering device to determine specific instrument design requirements. The wide dynamic range of the experiment, coupled with limitations on concentration and external access, will require careful synthesis of optical scattering measurement techniques. Phase II work will require further specialized development and fabrication of a prototype instrument for ground and microgravity applications. This project's work is relevant to the study of exobiology–the origin and evolution of life and life-

related processes and materials throughout the universe.

Potential Commercial Applications: The anticipated result is development of a modified optical instrument for aerosol particle measurements for application to particle size measurements in the range of 0.01 to 1000 microns. This instrument will have commercial applications such as carbon-black manufacturing and silica soot preparation for fiber optics manufacturing.

***

164 ARC
92-1-08.13-9411 NAS02-13775
A Dual, Diode-Pumped, Difference-Frequency, Mixing Source of 3 to 5 μm Radiation
Spectra Diode Laboratories, Inc.
80 Rose Orchard Way
San Jose, CA 95134
Robert J. Lang (408-943-9411)

Mid-infrared sources of coherent radiation are required for measurements of gas concentration and isotopic composition in exobiological measurements. Current sources of mid-IR radiation require either cryogenic temperatures or large, high-power ion, solid-state, and/or dye laser systems for driving nonlinear mixing processes such as optical parametric oscillators and difference-frequency mixing (DFM). This project will develop a rugged, compact 3 to 5 μm source of coherent radiation based upon difference-frequency mixing of the radiation from two, high-power, single-mode semiconductor laser diodes in a nonlinear crystal. This system offers room-temperature operation, wavelength tunability, a simple optical system, and simple control electronics. This all-diode-laser DFM system could be extremely compact, rugged, reliable, and would require no cryogenic cooling while providing tunable infrared radiation throughout the 3 to 5 μm region for laser spectrometry on terrestrial and planetary missions.

Potential Commercial Applications: Mid-IR sources are required for monitoring molecular composition in process control, medical monitoring, and pollution and environmental sensing. A small, rugged diode-based laser spectrometer based on the DFM source would help the development of a portable field instruments that can measure gas concentration and/or composition.

***

165 GSFC
92-1-08.14-5650 NAS05-32448
A Combined Optical Property Sensor for In Situ Characterization of Ocean Waters
Western Environmental Technology Laboratories, Inc.
P.O. Box 518
Philomath, OR 97370
Casey Moore (503-929-5650)

This project addresses the need for better tools to determine of the fundamental optical properties and biogeochemical composition of ocean waters. Global climate changes, widespread pollution, and increased ocean resource extraction have created an unprecedented need to better understand global ocean processes. With the advent of satellite-based remote sensing of ocean color, scientists now have a viable tool for the global study of the oceans. However, in order to correlate, interpret, and calibrate information from the remotely sensed data, a new class of in situ optical sensors are required. This project will develop a single sensor package to measure spectral downwelling irradiance, upwelling radiance, absorption, backscattering, and beam attenuation. Phase I will test a bundled optical package and design a tightly coupled inline instrument to be developed as the Phase II objective. The Phase II instrument will be designed for deployment on shipboard and towed profiling and moored applications.

Potential Commercial Applications: Commercial applications include satellite remote sensing, calibration, and validation; environmental research and surveying; oceanic waste disposal studies; engineering turbidity studies; mine tailing disposal monitoring and other environmental turbidity studies; underwater lidar communications; and fundamental ocean optics research.

***

166 GSFC
92-1-08.14-6522 NAS05-32408
Instrumentation for In Situ Measurement of Apparent Bio-Optical Properties
Analytical Spectral Devices, Inc.
4760 Walnut Street, Suite 105
Boulder, CO 80301
Brian Curtiss (303-444-6522)

While underwater spectroradiometers for the in situ measurement of apparent optical properties of seawater have been in use for some time, current in-water sensors do not fully meet the needs of the bio-optics research community. They either immediately measure a few selected wavelengths or require a minute or more to scan the spectrum. A high-speed, high-spectral-resolution spectroradiometer will be developed that can be autonomously deployed away from the influence of a ship's moorings, drifters, or towed profiling systems. The instrument allows reasonable sounding rates while providing simultaneous, high-spectral-resolution, in-water upwelling and downwelling measurements. NASA's planned advanced ocean color missions and the bio-optic research community require such an instrument to support calibration, in-water algorithm development, and validation of derived products. During Phase I, the project will complete the design for a high-speed, high-spectral-resolution radiometer capable of making simultaneous upwelling and downwelling radiation measurements in the 380 to 900 nm wavelength region. Next, the project will evaluate the performance

of this design relative to the performance of a prototype instrument based on an existing design. Finally, a calibration plan will be formulated as will the work to be performed in Phase II of this research.

Potential Commercial Applications: This research will lead to the development of a high-spectral-resolution spectroradiometer for the in situ measurement of apparent optical properties of water and for applications in water quality monitoring and assessment.

***

167 GSFC
92-1-08.15-0003A NAS05-32437
A Compact, Vacuum Ultraviolet Light Source Based Upon Dielectric-Barrier Discharge Technology
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Lawrence G. Piper (508-689-0003)

Phase I will conduct an experimental approach to demonstrate the innovative application of dielectric-barrier discharge technology for producing compact, high-flux, vacuum ultraviolet (VUV) light sources. This project will demonstrate a wide range of dielectric-barrier discharge VUV light sources, including line, molecular and continuum sources, and will explore in detail each source's long-term stability and reproducibility. The project will also compare the relative performance of dielectric-barrier and low power microwave discharge lamps. This project expects to demonstrate the superiority of dielectric-barrier discharge sources over currently used rf discharge sources in terms of compactness, flux, energy efficiency, and mechanical and electrical simplicity.

Potential Commercial Applications: These sources will find ready application in space experiments as onboard spectroscopic calibration sources and as sources of resonance radiation that can measure the number densities of upper atmospheric constituents. Their laboratory applications include use as calibration sources, light sources in spectroscopic and kinetic studies, and as sources of radiation for materials degradation studies. Commercially, the dielectric-barrier discharge light sources developed in this project will have application as calibration light sources, light sources for contaminant removal from surfaces, photo-etching of semiconductor surfaces, photo-assisted CVD processes, and various air and water purification processes.

***

168 GSFC
92-1-08.15-3661 NAS05-32425
Silicon Photodiodes with Integrated, Thin-Film Filters for Bandpass in the Extreme-Ultraviolet
International Radiation Detectors
2501 West 237th Street, Suite E
Torrance, CA 90505
Raj Korde (310-534-3661)

The company has recently developed silicon, p-n, junction photodiodes with stable, theoretically predictable quantum efficiencies in the vacuum-ultraviolet, extreme-ultraviolet, and soft x-ray (XUV) spectral regions, thereby leading to the diodes' use to establish an independent responsivity scale in these spectral regions. However, the developed diodes are sensitive to visible and near-infrared photons, which limits their versatility in many applications. This project will limit the bandwidth of the XUV photodiodes at selected extreme ultraviolet wavelengths by direct deposition of thin film filters. Phase I will investigate the fabrication of visible-blind, XUV silicon diodes with tellurium, titanium, tin, and aluminum-tin thin-film filters to obtain pass bands in 300 to 400 Å, 400 to 500 Å, 550 to 780 Å, and 530 to 720 Å, respectively. Phase II will investigate the direct deposition of interference filters for narrower pass bands in the vacuum and extreme ultraviolet region. In space research, these integrated detector-filter devices are in better than presently used, separate, free-standing thin-foil filters and detectors because they are more compact, bandpass stable, flexible, and reliable, as well as more easily manufactured and handled. This performance improvement occurs because the device's filter thickness is determined by the optical constants only and not by the mechanical strength requirement.

Potential Commercial Applications: The developed integrated filter-detector device will have a wide range of applications in the scientific fields, including soft x-ray radiometry, x-ray lithography, XUV astronomy, biological imaging in the "water window", and XUV spectroscopy. XUV spectroscopy is presently being used to determine chemical reactions at surfaces and chemical bonding information of different atomic species and to study spectra of the sun and distant stars.

***

169 GSFC
92-1-08.15-6000A NAS05-32444
Compact, Reliable Vacuum Ultraviolet Radiation Source
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Yi-Kang Pu (617-275-6000)

Ultraviolet and vacuum-ultraviolet (UV and VUV) light sources are needed for space simulation, flight experiments, and calibration of UV and VUV detection systems used in space science and plasma diagnostics. However, the performance of current commercially

available UV and VUV radiation sources is limited by instabilities in lamps, irreproducibility, window deterioration, uncertain aging characteristics, very narrow beams, and sensitivity to operating parameters. A compact, vacuum-UV radiation source based on electron-cyclotron-resonance (ECR) heated plasmas will be developed as a standard light source for space simulation and flight applications. The plasma will be produced by microwave heating of electrons. Light output can cover a wide wavelength range from visible to VUV with a broad uniform light beam so that UV degradation of large samples can be studied. This light source would be compact, efficient, inexpensive, and durable. Phase I will analyze and design the ECR, vacuum-UV radiation source based on experimental results from our current ECR source and theoretical calculations. Radiation spectra as a function of neutral gas pressure will be obtained. A compact ECR radiation source will be built and tested in Phase II.

Potential Commercial Applications: The VUV radiation source can be used as an intensity standard for plasma diagnostic calibration and development of photon detectors and optical components used by fusion and space science research laboratories and optical component manufacturers.

***

170 MSFC
92-1-08.15-6000D NAS08-39820
Oblique-Angle, Ion-Beam Sputtering for Mirror Finishing and Polishing
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Charles C. Blatchley (617-275-6000)

The firm will ion mill lightweight metals at cryogenic temperatures to demonstrate that amorphous surfaces and isotropic sputtering can be created in this way. If successful, this process will overcome the principal limitation of ion milling for many otherwise ideal mirror metals that tend to recrystallize and form texture due to differential sputtering. For each of several metals, the project will determine the angle of maximum sputtering at liquid nitrogen temperature. Since ions reaching the sides of a crack will necessarily sputter more slowly, typically by a factor of several times, this relatively oblique angle will rapidly remove micro-cracks. Asperities can similarly be removed by near-normal incidence, provided no new features are created in the process. The combination of select angles and low temperature should make it possible to ion polish virtually any mirror metal through an easily automated, highly deterministic process.

Potential Commercial Applications: The expected result is computer-controlled, one-load figuring and polishing of optical components to replace iterative mechanical finishing and measurement. Space and terrestrial telescopes, guidance, tracking, and remote imaging systems would benefit from both reductions in cost and improvements in mirror quality.

***

171 MSFC
92-1-08.15-8112 NAS08-39827
Thin-Shell Replication of Grazing Incidence Silicon-Carbide Mirrors
Sandia Systems, Inc.
2655-A Pan American Freeway, NE
Albuquerque, NM 87107
Scott R. Wilson (505-343-8112)

This effort will investigate the potential of chemical vapor deposition (CVD) silicon-carbide (SiC)with ion beam figuring to provide a fabrication technology for grazing incidence x-ray mirrors. The main goal of the effort is to develop the substrate technology for thin shell, very-near-net-shape and/or precision replication of single mirror elements for a Wolter type-I telescope. Attainment of this goal would demonstrate significant cost reduction and improved performance. A further objective is to design a Wolter type-I mirror for a Phase II demonstration. In Phase II, elements of a thin-shell design will be fabricated by the CVD, ion-beam figuring process. Another major portion of the effort is to demonstrate the applicability of ion beam figuring for processing the SiC elements, including the effects of a spatially variant ion beam removal profile.

Potential Commercial Applications: Thin-shell, low-cost, x-ray telescope mirrors for focusing synchrotron radiation would be applicable to biology, geology, materials science, and the commercialization of x-ray lithography.

***

172 JPL
92-1-08.16-0204 NAS07-1240
Ultra-Lightweight, Silicon-Carbide Mirrors for Cryogenic Infrared and Sub-Millimeter Reflectors and Grazing Incidence Applications
SSG, Inc.
150 Bear Hill Road
Waltham, MA 02154
Michael Anapol (617-890-0204)

NASA's advanced instrumentation requirements call for the development of large, ultra-low mass mirrors as a replacement for current glass and beryllium technologies. This project uses silicon-carbide (SiC) honeycomb, foam, and chemical vapor composites to achieve a revolutionary reduction in areal density from current 20 - 50 kg/m^2 to 2 - 5 kg/m^2. The company has demonstrated near-diffraction-limited performance at < 1 μm at 20 K on sample lightweight SiC mirrors. An IR&D program has produced a 3-inch sample mirror weighing only 15 grams and an ultra-lightweight structural assembly. This project extends the SiC lightweight mirror development to larger sizes with near-net-shape surfaces. Another application for SiC composites is grazing

incidence EUV mirrors; forming of the intricate mirror surface to near net shape is a critical attribute. Thin layers of silicon applied to the mirror surface easily achieve high quality, low-scatter surfaces by diamond turning and/or conventional polishing. SiC has superb stiffness, allows lightweight designs (equal to or better than beryllium), has superior thermal stability to cryogenic temperatures, and can be produced at low cost. The demonstration mirror fabricated in Phase 1 will have a ≈9" diameter with a weight goal of <0.2 kg.

Potential Commercial Applications: These mirrors can be used in infrared reflectors and airborne extreme-ultraviolet telescopes.

***

173 MSFC
92-1-08.16-6357 NAS08-39821
Concurrent, Local Wavefront Control Algorithms for Segmented Mirrors
Applied Mathematical Physics Research
P.O. Box 383
Lexington, MA 02173
Brian Hatfield (617-862-6357)

Building segmented primary mirrors from small identical segments allows the construction of large, active, and inexpensive optical telescopes. If the main purpose of the segmented primary is to provide atmospheric compensation, e.g., for power beaming, then diffractive effects which arise from this segmentation must be accounted for in the segment control objectives. These diffractive effects must also be considered in the physical design of the segmented primary mirror. This project addresses a variational calculation which would be the basis for a PC-based systems model for use at the system design stage. The systems model optimizes system performance, defined as the fraction of power on target for a power beaming system, by varying segment size, shape, and laser wavelength. Two parallel algorithms for segment control based on functional methods and a statistical database will be tested on a simulated segmented mirror (<100 segments). Phase II plans extend the parallel algorithms to large mirrors while optimizing parallel communication between segments.

Potential Commercial Applications: The segmented mirror control algorithms will have commercial application wherever inexpensive large optics are required or where compensating optics are needed. Applications include optical and infrared astronomy on the ground or in space, wireless power transport, optical communications, and real-time image recovery.

***

174 JPL
92-1-08.16-7990 NAS07-1238
Sub-Wavelength Structured Surfaces for Infrared Optical Elements
Rochester Photonics Corporation
80 O'Connor Road
Fairport, NY 14450
Dean Faklis (716-377-7900)

An important innovation for infrared optical systems is the use of sub-wavelength-period diffractive structures for the synthesis of polarizers, beamsplitters, and graded-phase optics. By patterning a substrate with a sub-wavelength-period structure, one can synthesize an effective refractive index distribution to implement certain optical functions including antireflection surfaces. This project's approach will be based on one- and two-dimensional, binary- and multi-phase-level diffraction gratings to synthesize various optical elements for the thermal infrared spectrum. A series of computer simulations, using rigorous coupled-wave theory and effective medium theory, will be performed. The dependence on such grating parameters as groove depth, duty cycle, and wavelength will be analyzed. Manufacturing constraints will be integrated into the designs, and key technologies required for fabrication of these advanced optical elements will be identified. Phase II will develop, fabricate, and test lightweight, infrared optical elements.

Potential Commercial Applications: Sub-wavelength structured surfaces may offer superior optical solutions for infrared sensor systems with applications in low observable technology, improving the efficiency of solar radiation detectors, high-density WORM optical data storage, and fiber-optics-based biosensors.

***

175 GSFC
92-1-08.17-6484 NAS05-32410
Collimators for X-Ray, Gamma Ray, and Neutron Astronomy
Artep, Inc.
6432 Elffolk Terrace
Columbia, MD 21045
Ronen Feldman (410-381-6484)

This project will develop a technique that will enable the construction of very-high-precision collimators with diameters of at least 10 cm. The collimators will be capable of modulating 90 percent or more of gamma rays to 200 MeV and neutrons to 500 MeV. The collimators will be constructed from thin foils of high density metal (presumably tungsten). The foils will be assembled to form collimators with slit dimensions equal to the foil thicknesses. The foil thickness can be 20 microns or wider. The foils will be held together by low-Z spacers, which will obscure in the visible less than 50 percent of the slits' field-of-view for 20-micron foils and less than 25 percent of the field-of-view for 100-micron foils. The standard deviation of misplacing the foils in the collimator assembly, which is defined as the

difference between the measured and the ideal locations, will be less than 10 percent of the collimators pitch (foil plus slit widths) for the 20-micron-foil assemblies and on the order of 5 percent for the 100-micron-foil assemblies.

Potential Commercial Applications: High-precision collimators may be used in laboratory x-ray and gamma-ray imaging of radiation emitted by accelerators or in future, modulating, Fourier transform microscopes which may be employed in medical and metallurgical applications. Future NASA missions may use collimators for imaging high-energy radiation from astrophysical objects. In particular, the collimator can be used on the high-energy solar physics (HESP) satellite.

***

176 JPL
92-1-08.18-0610 NAS07-1208
High-Power, Single-Mode Diode Lasers for 2 to 5 μm
Sensors Unlimited, Inc.
3490 U.S. Route 1
Princeton, NJ 08540
Gregory H. Olsen (609-520-0610)

GaInAsSb diode lasers will be fabricated for the 2 - 5 μm mid-infrared spectrum. This project will develop a method to grow these materials, both n- and p-type, by metalorganic chemical vapor deposition (MOCVD). Although MOCVD is the preferred fabrication method for diode lasers, due to its uniformity and manufacturing potential, no one to date has been able to grow n-type AlGaAsSb with more than 15 percent Sb (it always grows p-type). To accomplish this tasks, a radically new generator of stibine (SbH_3) gas, along with recently developed metalorganic precursors of Al- and Ga-compounds, will be used. Methyl precursors of Al, Ga, and Sb are believed responsible for the carbon incorporation that dopes the alloys p-type. Phase I will grow both n- and p-type AlGaAsSb and GaInAsSb, from which 3.5 μm lattice-matched lasers could be grown on GaSb substrates. Phase II will optimize other alloy compositions and device structures to make high-power, single-mode lasers for 2 to 5 μm emission at 200 - 300 K.

Potential Commercial Applications: The use of MOCVD to produce AlGaAsSb/InGaAsSb semiconductor lasers would reduce their cost so that they could supplant lead-salt lasers, which are the only ones now commercially available for 2 to 5 μm, although they have reliability problems, low power output, modal instabilities, and require cryogenic cooling.

***

177 GSFC
92-1-08.20-0755 NAS05-32428
Optical Fiber Pre-Amplifier for Infrared Detectors
Lightwave Electronics Corporation
1161 San Antonio Road
Mountain View, CA 94043
Henry Plaessmann (415-962-0755)

The project will develop a diode-laser-pumped, Nd_2O_3-doped, phosphate glass, single-mode-fiber pre-amplifier operating at 1.054 μm. The innovative aspect of the design is a pumping cavity. To make the pre-amplifier, a length of doped fiber is contained in a small volume. Next, the cavity is pumped by a high-power diode laser designed so that the pumped light cannot escape. Eventually, all the pump energy is absorbed by the Nd_2O_3-doped core. With a pump power of 500 mW and a 30 percent absorption efficiency, the expected gain is > 30 dB, the bandwidth is 10 GHz, and the DC-input equivalent dark signal is 2 nW. The design is compact and efficient, has an excellent lifetime, and is limited only by those systems which require detection of very weak signals such as those used in long distance communications and sensing. A single-mode-fiber pre-amplifier offers high gain, high sensitivity, and high bandwidth. The pre-amplifier is also suitable for laser amplification and laser oscillation as well. The Phase I objective is to determine the feasibility of the pump cavity concept. Next, the project will design, construct, and demonstrate a fiber pre-amplifier based on the pump cavity with performance approaching the above values. Laser performance will be demonstrated and characterized as well.

Potential Commercial Applications: Single-mode fiber pre-amplifiers and lasers are useful for long-distance, free-space, and fiber-optic communications; free-space and fiber-optic sensing; and optical ranging.

***

178 GSFC
92-1-08.20-0997 NAS05-32433
Low-Noise, Fiber-Optic Gyro for Inertial Reference Applications
Optiphase, Inc.
7652 Haskell Avenue
Van Nuys, CA 91406
Ira Jeffrey Bush (818-782-0997)

The goal of this project is to develop a high-performance, fiber-optic gyro that operates over the rates of 0.0015 to 1500 degrees per hour while having an extremely low noise of less than 0.00001 $(deg/hr)^2$ per Hertz and a bias repeatability of less than 0.0003 degrees per hour. The approach involves using low-cost, single-mode fiber with a coil length in excess of 10 km and a high performance polarizer. Phase I will design, fabricate, and test a breadboard fiber gyro that demonstrates this performance capability. This demonstration gyro will use telecommunications grade fiber and operate in laboratory ambient temperature condi-

tions. This type of fiber-optic gyro will benefit to space applications as the next generation rotational sensor for inertial reference units. It is intrinsically low-cost and low-weight and uses long-life components that are immune to electrical interference and resist radiation effects.

Potential Commercial Applications: This low-cost, low-weight, fiber-optic gyro will benefit NASA space applications and military and commercial sectors that need low-cost, long-lifetime gyros for highly accurate platform stabilization and inertial reference applications.

***

179 GSFC
92-1-08.20-7786A NAS05-32419
Stabilized Diode Laser for Laser Metrology
Environmental Optical Sensors, Inc.
3704 North 26th Street
Boulder, CO 80302
S. Eric Wheatly (303-440-7786)

NASA requires compact, rugged optical sources which have a stable reproducible center frequency and a long coherence length (narrow linewidth) for laser metrology applications. This project will use a Doppler-free, two-photon absorption (DF2PA) transition in an alkali vapor as an absolute frequency reference that in turn is used with negative electrical feedback to stabilize a diode laser and narrow its linewidth. This approach offers a wider choice of wavelengths (including visible) than an approach using a saturated resonance line. The objectives in Phase I are to demonstrate stabilization and line narrowing using DF2PA, to identify and minimize the factors which affect the absolute stability of the laser, and to build a compact prototype packaged laser using this approach. The Phase I effort includes modeling specific 2PA transitions, constructing and evaluating various reference cells, and constructing a prototype packaged laser. The result of Phase I will be operational prototype laser hardware and an understanding of how to design flight-qualified hardware to NASA specifications. The availability of a space-qualified stabilized diode laser will be useful to NASA for laser metrology, especially absolute distance measurements in space to assist in assembly of structures. Other applications include improved optical sensors, remote sensing, and communication.

Potential Commercial Applications: Potential commercial applications for stabilized lasers are precision metrology (such as distance measurement), fiber optic sensors (such as laser gyroscopes), and wideband optical communications systems.

***

180 GSFC
92-1-08.20-9411 NAS05-32442
Visible Laser Diodes Operating from 0.45 to 0.7 μm
Spectra Diode Laboratories, Inc.
80 Rose Orchard Way
San Jose, CA 95134
Jo S. Major, Jr. (408-943-9411)

This project will develop visible semi-conductor laser materials and devices spanning the wavelength range of 0.45 to 0.7 microns. The approach allows for lattice-matched growth of high-bandgap III-V semiconductors on lattice-matched III-V substrates with similar processing parameters to that of GaAs. It is anticipated that efficient generation will span the entire visible spectrum. Laser diodes fabricated in high-bandgap III-V materials will represent a breakthrough technology resulting in the development of reliable visible laser diodes that operate CW at elevated temperatures and high power.

Potential Commercial Applications: These compact visible sources will find applications in the technology bases of NASA, the U.S. military, and the world marketplace. Specific applications for visible light emitters include illuminators, high-density optical storage, high-temperature electronic devices, visual displays, color printing, color reprographics, media-specific electronic communication links, and medical applications. NASA will be able to use the visible laser diodes for high-brightness visible displays, illuminators, and high-performance optical data read-write operations.

***

181 JPL
92-1-08.21-0610 NAS07-1230
A Rugged, Compact, Near-Infrared Reflectance Spectrometer
Sensors Unlimited, Inc.
3490 U.S. Route 1
Princeton, NJ 08540
Marshall J. Cohen (609-520-0610)

A compact, low-power, near-infrared reflectance spectrometer will be developed for use in spacecraft missions. The innovation consists of integrating a custom-designed, dielectric stack "wedge-filter" with a low-noise, room-temperature InGaAs photodiode array. In Phase I, a prototype system for the 0.9 to 1.7 μm wavelength band will be built and delivered. In Phase II, a complete system for 0.9 to 2.5 μm, including all hardware and associated electronics, will be built and delivered.

Potential Commercial Applications: This spectrometer will have such terrestrial industrial applications as the determination of the water content of grains and food products, the on-line measurement of the octane rating

of gasoline, the measurement of the alcohol content of beverages, and the control of coating processes.

***

182 JPL
92-1-08.21-7200 NAS07-1209
A Very Compact, Light-Weight, High-Speed, Rugged, Near-Infrared Spectrometer
Brimrose Corporation of America
5020 Campbell Boulevard, Suite E
Baltimore, MD 21236
Sean X. Wang (301-931-7200)

This project will develop a miniature infrared spectrometer based on an integrated-optic, acousto-optic tunable filter (IOAOTF) fabricated in an optical waveguide. The optical spectral analysis is accomplished by the TE-TM mode conversion in the optical waveguide due to the anisotropic acousto-optic interaction. The fast wavelength tuning (10 μs) with narrow passband (several nm) over a wide bandwidth (0.9 to 2.5 μm) is made possible by an acoustic dynamic grating controlled by simply changing the acoustic frequency. In combining state-of-the-art guide-wave technology, integrated optics, and acousto-optics, this IOAOTF infrared spectrometer offers advantages of light weight (<1 gram), small size (10 x 5 x 1 mm), low power consumption (<100 mW), high sensitivity, reliability, ruggedness, self-calibration, and potentially very low cost.

Potential Commercial Applications: The device will have applications in remote sensing, chemical process control, medical diagnostics, and control and monitoring of environmental pollutants and contaminants.

***

183 JPL
92-1-08.22-8181 NAS07-1222
A Simultaneous, Electronically Variable, Multi-Spectral Imaging System
Photonic Systems, Inc./MVM Electronics, Inc.
1800 Penn Street, Suite 4B
Melbourne, FL 32901-2625
Manhar L. Shah (407-984-8181)

This project will develop a simultaneous, electronically variable, multi-spectral imaging system using two polychromatic acousto-optic tunable filters and a set of dichroic beam separators. The approach offers advantages in simplicity, electronic tunability, large field-of-view, small size, and high optical throughput that make it highly desirable for spaceborne applications. The system will be designed to obtain twelve narrow-band images in two groups for two polarizations at six spectral positions that can be varied over a designated range without any dead region within the visible range. This system is expected to provide maximum flexibility, minimum size, and lower power consumption. In addition, the orthogonally polarized, simultaneous, narrow-band images and experience with charge-coupled-device array control and image acquisition will enhance the system's polarimetric, analytic, and image processing capabilities.

Potential Commercial Applications: A simultaneous, multi-spectral imaging system, with its parallel processing capabilities, would be a powerful tool for understanding and analyzing the composition of galaxies, the atmosphere and terrain of planets, and rocks; the dynamics of weather, explosions, and flames; and the distribution of crops, minerals, and pollutants. Uses in chemistry, mining, metals, ceramics, drugs, image processing, and mapping are also possible.

***

184 SSC
92-1-08.24-2116 NAS13-556
Optical Sensor Calibration by the Touchstone Technique
Computer Optics, Inc.
120 Derry Road
Hudson, NH 03051
Jack Schwartz (603-889-2116)

In Phase I, non-invasive optical sensors will be calibrated by a unique method of applying interpolating transformations anchored by calibration points. This sensor characterization method is called the Touchstone technique of calibration. Calibration in the optical spectrum requires two disciplines: understanding the nature of electro-optical signal generation and the mechanism of precise correction of the sensor output for the known input signal. Normally, point by point corrections do not automatically apply between calibration points. With the Touchstone technique, maximum errors between these points are controlled. For each desired sensor response characteristic, position, intensity, MTF, field-of-view, and S/N, suitable test inputs and a corresponding mapping algorithm will be designed using the Touchstone technique. This dynamic calibration system will be directly applicable to NASA requirements for calibrated sensors for the visible, near-infrared, and far-infrared spectral ranges.

Potential Commercial Applications: Applications include calibration devices for the machine vision industry and the automotive, aircraft, pharmaceutical, and electronics industries. Other uses are in measurement of steel sheet, wire, pharmaceutical units, and micro-electronic circuit production lines.

***

185 SSC
92-1-08.24-2650 NAS13-554

An Adaptive Filter Approach to Auto-Calibration of Spectroscopic Instruments

Biotronics Technologies, Inc.
W226 N555B East Mound Drive
Waukesha, WI 53186
Kenneth J. Schlager (414-896-2650)

Spectroscopic instruments used in chemical analysis have made significant advances in "re-agentless" quantitative assays performed in industrial, environmental, medical, and space applications. These instruments are noninvasive because they perform measurements nondestructively and without interference to the process. While progress has been particularly noteworthy in the near infrared spectral region, quantitative spectrometric analysis has been handicapped by the continuing need for complex calibration procedures. Typical regimens require 50 to 200 labeled samples in "learning sets" to calibrate each instrument. These calibration procedures must also be repeated periodically to reflect changes in process characteristics or instrument drift. The goal of this project is to develop a new approach to spectroscopic instrument calibration that does not require multiple labeled samples. This new technique is based on adaptive filter technology that allows the instrument to continually re-adjust its calibration in the field. The only exogenous input requirement is a standard spectrum of each sample of interest. This innovation in calibration promises to greatly expand the applications of many forms of spectrometry in quantitative analysis.

Potential Commercial Applications: Adaptive spectroscopic calibration will greatly expand the market for on-line and noninvasive near-infrared absorption, ultraviolet-visible absorption, fluorometric, and atomic-emission spectrometry in environmental, medical, industrial, and space applications.

***

186 SSC
92-1-08.25-9049 NAS13-555

Hydrogen-Chloride Sensor Based on Conducting Polymers

Gumbs Association, Inc.
11 Harts Lane
East Brunswick, NJ 08816
Guang-Way Jang (908-257-9049)

The project addresses the problem of monitoring the emissions from the exhaust plumes of solid rocket propellant engines. The approach involves sensitive hydrogen-chloride (HCl) sensor systems that consist of arrays of basic sensor cells constructed using chemical-electrical response characteristics of conducting polymers. The concept is based on the very sensitive and highly reversible dependence of electrical conductivity and absorption peak of certain conducting polymers when exposed to HCl gas. The specific conducting polymer systems to be studied include polyaniline, substituted polyaniline, and poly(diphenylamine). Other -NH- bridged conducting polymers will also be examined to optimize the desired operational characteristics of sensor systems. The resulting protonation and/or doping of the -N= sites leads to characteristic conductivity versus HCl concentration curves, which can be calibrated to produce reliable instantaneous readings of the HCl concentrations at various points in the active rocket exhaust area. It should be possible to couple highly sensitive nuclear-magnetic-resonance microprobes to the sensor cells to monitor quantitatively the proton levels in the sensor elements.

Potential Commercial Applications: The technology has wide applicability and commercial potential for chemical and biochemical sensors, including gases, vapors, smokes and other contaminants. Using a matrix of microsensor elements, the technology can be extended to sense chemical compounds with specific structures.

***

187 HQ
92-1-08.26-0099 NASW-4783

Surface Acoustic Wave Device as Micro-Deposition Sensor

Microsensor Systems, Inc.
62 Corporate Court
Bowling Green, KY 42103
H. Wohltjen (502-745-0099)

Surface acoustic wave (SAW) technology is a promising approach for the development of microsensors for monitoring the deposition of small amounts of ion-sputtered material in a spacecraft environment. SAW sensors and their supporting electronics have the inherent advantages of being very small, lightweight, low power, and low cost. They can also accurately detect changes in mass of deposited material of 1 nanogram or less. The only disadvantage of SAW sensors is their known temperature sensitivity. Therefore, this project will develop a method for reducing the effect of the temperature of SAW sensors over the temperature range anticipated for spacecraft applications. Many approaches will be used to reduce SAW temperature dependence: selection of a quartz substrate with well-characterized temperature response, active control and measurement of the SAW surface temperature, and development of a temperature compensation algorithm to correct automatically for any residual temperature dependence.

Potential Commercial Applications: Reduction or elimination of SAW temperature sensitivity will greatly extend the technology's range of commercial application for environmental and industrial monitoring.

***

188 JPL
92-1-08.26-6239 NAS07-1228
A 200 MHz Surface-Acoustic-Wave Resonator Micro-Deposition Monitor
Femtometrics
1001 West 17th Street, Suite R
Costa Mesa, CA 92627
W.D. Bowers (714-722-6239)

The quartz crystal microbalance (QCM) has been the accepted instrument to monitor molecular deposition on a spacecraft surface so that the level of surface contamination can be determined. The mass sensitivity of the present QCM, 0.23 Hz cm^2/nanogram for a 10 MHz crystal, cannot meet the 1 nanogram/cm^2 required by NASA. A new type of piezoelectric crystal, a 200 MHz surface-acoustic-wave (SAW) resonator, piezoelectric crystal, could increase the mass sensitivity two orders of magnitude over the conventional bulk crystals. A 200 MHz, SAW-resonator, mass microbalance has been developed for aerosol measurements and could be used to measure microdepositions. With a sensitivity of 90 Hz cm^2/nanogram, such a SAW device can monitor the 1 nanogram/cm^2 deposits with a frequency shift of 90 Hz, which is about 400 times that of a 10 MHz bulk crystal (per unit area). By transferring the firm's SAW mass microbalance technology and by using the existing QCM technology, an efficient and cost-effective program is possible to develop a small, lightweight, space-certifiable microdeposition monitor.

Potential Commercial Applications: A small, lightweight, space-certified, SAW-resonator microdeposition monitor would provide an economical, compact, reliable, and extremely sensitive instrument to measure molecular mass deposition in both vacuum chambers and space simulation chambers, and in applications such as the space station.

***

189 JPL
92-1-08.27-6000 NAS07-1210
Feedback-Controlled, MetalOrganic-Chemical-Vapor-Deposition Reactor for the Indium-Gallium-Arsenic-Phosphorus Materials System
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396
Nasser H. Karam (617-275-6000)

MetalOrganic chemical vapor deposition (MOCVD) is the leading material technology for fabricating III-V multilayer structures for semiconductor devices. Whereas these devices require precise control of composition and thickness to maintain high yield and performance, current MOCVD growth processes operate in an uncontrolled mode and require frequent calibration runs to maintain reproducibility. These deficiencies result in reduced yield and throughput and, therefore, increased costs. The goal of Phase I is to identify and demonstrate the feasibility of compatible sensor technologies which can provide in-situ monitoring and feedback control of wafer growth in the InGaAs(P)/InP material system. The approach will implement two types of sensors. The first measures the concentration of the reactant sources in the gas phase. This information is then used to provide real-time control for the growth-rates and compositions of the deposited thin films. The second sensor is a wafer that measures thicknesses and compositions of films as they are deposited. The project will design a highly uniform, single-wafer, reaction chamber that incorporates the control sensors. Next, Phase I will establish the feasibility of the key sensors by conducting a breadboard demonstration. In Phase II, the reaction chamber will be built and real-time feedback control will be demonstrated.

Potential Commercial Applications: Development of a feedback-controlled reactor will significantly advance the state-of-the-art in MOCVD materials growth. Feedback-controlled reactors will be attractive to manufacturers of multi-layer III-V devices such as diode lasers and solar cells. Additionally, the ability to produce complex structures at significantly improved yields will result in the lower cost of commercial wafers.

***

190 HQ
92-1-08.28-7780 NASW-4787
X-Ray Analysis of Materials Degradation in Space
Advanced Research & Applications Corporation
425 Lakeside Drive
Sunnyvale, CA 94086
Jonathan A. Kerner (408-733-7780)

The project will develop and demonstrate a portable, x-ray dispersive analysis instrument which supports the non-intrusive characterization of the chemical degradation of materials in space. The instrument integrates a powerful chemical-state analysis capability into a portable, space-deployed package. The objective of the Phase I project is to establish the sensitivity of the instrument to the surface chemical state of a representative spacecraft material, a thermal control film. To achieve this objective, the Phase I effort will assemble, operate, and analyze data produced by a breadboard instrument. The anticipated result of the project will be an experimental database that supports selection of applications for the instrument in Phase II. This project will give NASA a new capability for conducting non-intrusive maintenance examinations during long-duration missions.

Potential Commercial Applications: The x-ray dispersive analysis instrument is expected to serve multiple process-control and quality-assurance non-destructive examination roles in the semiconductor device and other materials-intensive industries and to support portable monitoring applications for environmental compliance.

***

191 HQ
92-1-08.28-9806 NASW-4796
Detection of Thermal Damage in Space Vehicles Using A Fourier-Transform-Raman Spectrometer
Advanced Fuel Research, Inc.
P.O. Box 380379
East Hartford, CT 06138-0379
Stuart Farquharson (203-528-9806)

A number of advanced, fiber-reinforced, organic-matrix composites are being developed and applied in the aerospace industry. In these applications, the composites may be exposed to a variety of harsh environments that may induce chemical and physical changes in the composite material and ultimately lead to component failure. Therefore, the successful use of these composites requires methods to reliably detect and assess these changes. Although numerous techniques have been developed and employed to analyze the chemical, physical, and mechanical properties of composites as well as to define material flaws, none of these techniques is amenable to at-site inspection of in-use components with the capability of assessing the effect of damage on future product performance. This project will develop and employ a fiber-optic-based, Fourier-transform-Raman spectrometer for the non-destructive evaluation of thermally damaged composite materials. The system will correlate thermally induced changes in Raman spectral features to changes in mechanical properties. During Phase I, these measurements will be used to quantify the degree of thermal damage. During Phase II, this information will be used to develop a methodology to predict future component performance. Also during Phase II, a prototype instrument with an extended fiber optic probe will be developed with the potential of accessing an entire space vehicle.

Potential Commercial Applications: The anticipated result of this project is an instrument with a flexible sample probe capable of assessing the effect of thermal damage on future performance of composite materials. It could also be applied to the analysis and assessment of a broad range of composite and substrate materials. Because the instrument is designed to be rugged, portable, and user friendly and can perform analysis in near real-time, it is capable of use in process-control situations.

***

09: Spacecraft Systems and Subsystems

192 GSFC
92-1-09.02-0092 NAS05-32405
Robust Control Integration Software for Spacecraft Applications
American GNC Corporation
9131 Mason Avenue
Chatsworth, CA 91311
Ching-Fang Lin (818-407-0092)

Future spacecraft are required to have high precision in the presence of disturbances, uncertainties, and component failures. Consequently, the task of modeling and control becomes extremely demanding. To be developed in this project, a package of robust control integration software that augments the existing interactive control analysis (INCA) program will provide a set of robust control design and modeling methods using a unified algorithm and common framework. It will be able to perform linear quadratic Gaussian design, H^∞ design, μ synthesis, covariance control, mixed H^2/H^∞ design, robust eigenstructure assignment, mixed H^∞/H^∞ design, positivity design, and many others for large order space systems. The software also features an interactive interface so that the control analysis and design of space systems can be simplified. The deliverables include a design and analysis tool that is totally compatible with the existing INCA program, together with comprehensive documentation and training courses.

Potential Commercial Applications: The development of the robust control integration software can significantly enhance the spacecraft control analysis capability. The tool will be commercialized for other control-related applications.

***

193 GSFC
92-1-09.02-5500 NAS05-32447
Robust Control Design by Q-Parameterization
Swales & Association, Inc.
5050 Powder Mill Road
Beltsville, MD 20705
Nicholas G. Stamatakos (301-595-5500)

As stability and performance specifications for controls systems become more and more challenging, controls designers will be forced to implement complex, multivariable control laws. This trend has created the need to upgrade software tools, such as interactive controls analysis (INCA), to incorporate these new control methodologies as they are being developed and implemented for aerospace and other engineering applications. Currently, system or component transfer functions are entered to mathematically model control systems in INCA. The new control methodologies require that the system dynamics be modeled in state-space form. The objective of this project will be to modify INCA to accept input for a control system model

in state-space form, to convert transfer functions to state-space (and vice versa), and to implement robust control laws first for SISO (single input, single output) systems and then for MIMO (multi input, multi output) systems in Phases II and III. Once developed and tested, these additions to INCA will give the controls engineer a tool for developing and implementing robust control methodologies for control systems.

Potential Commercial Applications: The software developed will be useful in government and commercial applications requiring classical and/or modern design techniques (e.g., unmanned spacecraft, payload pointing systems, instrument control systems, aircraft, factory automation). The software will serve as a useful learning tool for engineers and graduate controls students.

***

194 LaRC
92-1-09.03-9106 NAS01-19892
Integrated Control System for Aerospace Plane Using Stochastic Nonlinear Optimal Control
Neurodyne, Inc.
8 Marlborough Street, Suite 4
Boston, MA 02116
Theresa W. Long (617-437-9106)

The design of the vehicle control system for an aerospace plane presents a tremendous challenge due to the strong coupling between translational, rotational, structural, thermal and engine dynamics and control, and the extensive range of operating conditions. While the conventional approach begins by dividing the overall vehicle control task into subtasks, this approach must be augmented with higher level controllers that coordinate the lower level controllers and insure that more global control system requirements are achieved, such as adaptation and fault tolerance. This effort will develop and evaluate an integrated controls approach that combines optimal control methods with neural-network-based system identification. These techniques will be applied to the NASA-Langley hypersonic vehicle model. The investigators will leverage current research programs in neural computing applications to integrated flight and propulsion control and NASP thermal management. The system will be developed to integrate with the ascent guidance logic in a hierarchical manner using an inner-outer loop configuration developed by the firm for decentralized control of distributed coolant flow for hypersonic vehicles.

Potential Commercial Applications: Adaptation of control systems to unanticipated changes in aircraft dynamics provides not only a method for optimal performance over the life of the engine but the potential ability to reconfigure integrated flight and propulsion control laws in the event of in-flight damage or failure. Furthermore, the development of neural software-hardware optimization methods could significantly enhance future mission effectiveness of NASA and commercial flight vehicles.

***

195 JPL
92-1-09.04-0092 NAS07-1212
Intelligent Spacecraft Guidance and Control
American GNC Corporation
9131 Mason Avenue
Chatsworth, CA 91311
Ching-Fang Lin (818-407-0092)

Future spacecraft are required to achieve pinpoint accuracy in the presence of onboard disturbances, uncertainties, and component failures. The design challenges of precision control, structural vibration suppression, health monitoring, autonomous operation under an unknown dynamic model, severe disturbances, significant uncertainties, and unexpected failures are accommodated using an intelligent control approach. The intelligent, fuzzy neural system is able to identify on-line the multivariable dynamics of the spacecraft; realize the robust stabilization and slewing control requirements; detect, isolate, and accommodate faults in real time; and perform autonomous decision-making and control operations. The intelligent control approach can improve the precision control, fault tolerance, reliability, availability, and life-cycle cost effectiveness of future space systems.

Potential Commercial Applications: The development of intelligent control technologies can be applied to many industrial and commercial systems. The fuzzy neural controller can be used for flying vehicle stability margin augmentation, ground vehicle active suspension control, and underwater vehicle acoustic level reduction. The product developed can also be used for the design of autonomous systems.

***

196 LaRC
92-1-09.05-0540 NAS01-19897
A Low-Cost, Feedback-Controlled, Anti-Gravity Suspension System
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Richard L. Hockney (617-661-0540)

A system is needed to simulate the unconstrained boundary conditions of orbital flight in ground vibration testing on a variety of highly flexible (low frequency) structures. Existing approaches introduce undesirable mass, damping, and stiffness into the test article-suspension device system, reducing the effectiveness and validity of the ground tests. The company will develop a suspension system for simulating on-orbit boundary conditions in dynamic testing of very low frequency structures. The suspension device consists of low-cost cable support modules that actively control the

support cable tension to a precise, constant value. These modules are capable of providing vertical rigid-body suspension frequencies low enough to isolate highly flexible structures without adding unwanted mass, stiffness or damping. The suspension device will allow unconstrained vertical test article motion of +/- 6 inches, a large enough envelope to perform meaningful vibration tests. The device will also be able to operate in a vacuum chamber without significant loss of performance. Phase I will include construction and testing of a single-point suspension device for proof-of-concept demonstration. Phase II will develop the concept into a full system using multiple devices of the same design.

Potential Commercial Applications: A convenient means of testing light, flexible space structures in a one-gravity environment offers many advantages to commercial or federal organizations involved in building and testing structures for use in a zero-gravity environment. The low-cost, feedback-controlled, anti-gravity suspension system offers an "off the shelf" modular means of achieving this aim and distinct technical advantages compared to existing facilities and concepts.

***

197 LaRC
92-1-09.05-1500 NAS01-19891
Graphical Interactive Control Design and Implementation Environment
Integrated Systems, Inc.
3260 Jay Street
Santa Clara, CA 95054-3309
Robert L. Kosut (408-980-1500)

This project will develop an integrated control design and real-time implementation environment. The user will interact solely through a high-level, graphical user-interface and will no longer need to know the low-level functionalities. With this type of environment, the control designer can focus on the specific design problem at hand. The complexity of the underlying tool is advantageous because less conservative control design problems can be formulated. The problem is posed and solved without being overloaded by the details of the underlying toolbox. The environment will prove its efficacy by its ease in handling repetitive design and implementation stages for large space structure problems. Phase I will research the feasibility of such an environment with currently available tools. Phase II will develop and test software on an actual system using real-time hardware.

Potential Commercial Applications: The potential product from this work will complement the newly developing, object-oriented, computer-aided control system design tools. Such tools will impact significantly on prototyping and real-time implementation for commercial and government applications.

***

198 MSFC
92-1-09.06-0520 NAS08-39836
Unobtrusive Sensor and Effector Technology with Optical Applications
Garman Systems, Inc.
One Blue Ridge Court
Getzville, NY 14068
Marco D'Amore (615-343-0520)

This project's goal is to develop an unobtrusive sensor and effector (USE) to provide nanometer-level displacement control with bandwidths to 20 kHz and beyond. The effector will need a displacement of 20 micrometers with a resolution of 20 nanometers. A self-sensing circuit will allow a single active element to serve as both a sensor and an actuator for this device. This self-sensing actuator generates both position and time rate of position signals. A simple proportional-derivative or a proportional-integral-derivative control in the system will set performance parameters such as settling time and overshoot. Various smart and/or active materials, such as piezoceramics and electrostrictives, will be investigated for application in the USE. Smart materials have hysteresis between the applied voltage and displacement; this project will determine the degree to which this displacement effect will change the utility of the servomechanism. The USE actuator will then be incorporated into the design of a precisely controlled, optical antenna subsegment. This work will provide a feasibility study for the development of the USE and determine if both the USE and the antenna subsegment can meet their targeted specifications.

Potential Commercial Applications: Although the work will investigate its application to adaptive optical systems, the USE device has potential applications in both acoustics and as a micromanipulator. The self-sensing technology that allows a single active element to act both as a sensor and an actuator will be developed for commercial applications.

***

199 MSFC
92-1-09.06-0540 NAS08-39828
Passive and Active Damping Enhancement Using Magnetostrictive Transduction
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Ralph C. Fenn (617-661-0540)

The controller-to-mass ratio of space structures can be reduced by devices which combine sensing and actuation functions. Magnetostrictive materials are well-suited for self-sensing but have typically been used only for actuation. "Reverse" transduction from the mechanical into the electrical domain presents the opportunity to remove large amounts of strain energy from the magnetostrictive material and the adjacent structure. This project describes how the effective material loss factor of a magnetostrictive material can be very high when

used with a passive dissipation network. This method of damping is superior to competing piezoelectric, viscoelastic, and proof-mass dampers because of its low mass, low volume, durability, mechanical simplicity, low voltages, remote dissipation capability, and temperature insensitivity. This project will also address the use of magnetostrictive transducers to sense strain rate for active damping enhancement. Both techniques will provide high damping, bandwidth, and resolution in a low mass device suitable for use in space structures. This work includes modeling and optimizing a passive magnetostrictive damper. A magnetostrictive strut will also be modeled as a velocity sensor, optimized for active control, and tested for its validity. A Phase II application will be determined, and a baseline configuration and network will be designed. The expected result will be a low mass, self-sensing magnetostrictive damper design with high loss factors, high bandwidth, and high resolution.

Potential Commercial Applications: The magnetostrictive damper will be dramatically lighter, smaller, mechanically simpler, and less temperature sensitive than existing designs. Lightly damped structures such as robotic arms will benefit from the design's high damping, low mass, small size, and zero backlash. Machinery and vehicle vibrations and noise will be damped by magnetostrictive struts used as mounts and structural members.

***

200 GSFC
92-1-09.07-0200 NAS05-32434
Packaging of Opto-Electronic Integrated Circuits for Space-Based Applications
Optivision, Inc.
4009 Miranda Avenue
Palo Alto, CA 94304
Robert F. Kalman (415-855-0200)

The emerging generation of opto-electronic integrated circuits (OEICs) can be used to implement very compact, rugged optical interconnects ideal for space-based applications. OEICs have demanding packaging requirements, including multiple fiber-optic interfaces and large electrical pin-out and may dissipate significant power. New packaging techniques will be developed to address the needs of OEICs such as optical crossbar switches in space-based environments. This project will investigate and develop multi-fiber optical interfacing techniques based on the use of planar SiO_2 optical waveguides on a silicon substrate. SiO_2/Si waveguide technology may provide high-performance, low-cost, compact, rugged optical interfaces that can be applied to a broad class of OEICs. The application of current advanced electronic and opto-electronic packaging to OEICs will be explored, including the use of advanced metals and ceramics, thermoelectric cooling, and flip-chip device mounting. Package performance over a range of environmental conditions (temperature, acceleration, radiation) will be investigated. A candidate OEIC will be selected for packaging during Phase II, and a detailed package design will be developed for this device.

Potential Commercial Applications: This research project addresses key design and feasibility issues in the packaging of opto-electronic integrated circuits. The research will provide needed packaging technology for the use of OEICs in a wide variety of NASA, DoD, and commercial applications, including fiber-optic networks, optical backplanes, and phased array antennas.

***

201 GSFC
92-1-09.07-1100B NAS05-32403
Dielectric Isolation for Silicon Carbide
Advanced Technology Materials, Inc.
7 Commerce Drive
Danbury, CT 06810
Charles P. Beetz, Jr. (203-794-1100)

This project addresses the need for semiconductor devices capable of withstanding long-time exposures in harsh environments to high radiation levels and elevated temperatures. An isolation technology for SiC will be developed that is similar to the SIMOX process developed for silicon, which permits fabrication of extremely radiation resistant, nonvolatile memory devices. The next generation of high-performance, radiation-tolerant electronic device technology will be based on wide bandgap semiconductor materials such as SiC, GaN, and diamond. Of these, silicon carbide is the most promising material for near-term applications. This isolation technique is based on a novel co-implantation and rapid thermal annealing process that will enable the formation of a thin SiC layer, electrically isolated for the bulk wafer that can be used for epitaxial film growth and device fabrication. This method of device isolation has many advantages for reducing leakage currents, increasing data storage times, reducing power consumption, and lowering costs by simplifying device design and fabrication. In Phase II, the barrier implantation and surface recrystallization processes will be optimized, and simple nonvolatile charge storage devices will be fabricated on prototype substrates. Long-term feasibility will be assessed, and a simple, nonvolatile memory device prototype will be fabricated.

Potential Commercial Applications: Applications of this technology will include in-situ sensors for radiation-intense environments and on-board control circuitry for aircraft engine control, power electronics for the space station, instrumentation for nuclear power systems, and tactical air-launched missile systems.

***

202 GSFC
92-1-09.07-4545 NAS05-32427
Waveguide Hologram Star Coupler
Jackson & Tull Chartered Engineers
7375 Executive Place, Suite 200
Seabrook, MD 20706
Qiang Huang (301-805-4545)

An innovative optical interface technique that allows for new, fiber-optic coupler designs will be developed. This new waveguide hologram (WGH) coupler will utilize holographic gratings to couple optical signals from fiber optic cables into and out of a waveguide. The waveguide performs the power combining and splitting functions of the star coupler. This new coupling technique will allow the development of a rugged, reliable, multiport star coupler that allows for more capacity in NASA spaceflight data systems. This work will determine the critical parameters for designing a prototype WGH star coupler for fiber optic systems.

Potential Commercial Applications: Fiber optic interfaces have constrained and limited the use of fiber optics technology in both commercial and government applications. This work will introduce innovative methods that will provide new packaging solutions and products for interfacing fiber optics and integrated optics. The WGH coupler technology, when it is applied to commercial products, has the potential for eliminating fiber pigtails and providing size, weight, and reliability advantages.

***

203 GSFC
92-1-09.08-0292 NAS05-32415
Cryogenic, Capillary, Pumped Loop
Cullimore & Ring Technologies, Inc.
49 Dawn Heath Circle
Littleton, CO 80127
Brent A. Cullimore (303-971-0292)

A capillary pumped loop (CPL) will be developed for use in cryogenic applications such as infrared sensor cooling and long-term cryogenic storage. CPLs not only overcome some of the obstacles encountered in missions requiring cryogenic heat pipes, their important performance improvements extend their use into applications not currently within the reach of heat pipes. Important advantages of CPLs over heat pipes include improved ground testability due to greater capillary pressures; improved mechanical isolation due to the use of long, thin flexible lines; faster diode shut down and fewer reverse heat leaks; elimination of thermal switches in redundant cryocooler applications through the use of proven condenser flow control techniques; tighter control of detector temperatures without increasing the rejection load; and higher performance and greater ease of integration because CPLs can be assembled from components. Phase I will experimentally verify the operation of a capillary evaporator pump using a cryogenic working fluid and will analytically explore design options that enable start up from a supercritical state.

Potential Commercial Applications: Immediate applications in the aerospace industry include the production of cold temperatures for cryogenic sensors and detectors, and the long term storage of cryogenic liquids for propulsion, environmental control, and sensor cooling applications. Another emerging application is in the cooling of cryogenic electronics for the next generation of computers.

***

204 GSFC
92-1-09.08-5500 NAS05-32446
Microcomputer-Based Spacecraft Thermal Analysis Software
Swales & Association, Inc.
5050 Powder Mill Road
Beltsville, MD 20705
Nicholas M. Teti (301-595-5500)

Thermal analyses of large-scale spacecraft are currently being performed with industry standard programs such as SSPTA, TRASYS, and SINDA. These software packages, however, are based on solution algorithms that were developed for hardware manufactured as much as 25 years ago. In recent years, the computer industry has made tremendous technological advances in providing powerful, yet inexpensive, desktop computers capable of competing with small mainframe computers. Using currently available software and hardware tools, this project will develop a new thermal analysis package for spacecraft to replace the current SSPTA and TRASYS programs. The program will include both diffuse and specular analysis capabilities, a user-friendly graphical interface, interactive model generation and plotting capabilities, and an interface to read existing SSPTA and TRASYS geometry files as well as output in SINDA and GSINDA compatible formats.

Potential Commercial Applications: Software developed under this project will provide the aerospace industry with an efficient and inexpensive tool for analyzing spacecraft thermal problems. The modularity of the software will allow for customization to meet specific customer requirements and will facilitate future upgrades to meet the growing needs of the industry.

***

205 GSFC
92-1-09.08-7500 NAS05-32417
Bubble Tolerant Capillary Pumps
Dynatherm Corporation
One Beaver Court, P.O. Box 398
Cockeysville, MD 21030
David A. Wolf (410-584-7500)

Small-diameter capillary pumps are currently being considered for capillary pumped loop (CPL) applications because they are smaller and lighter than large pumps. Unlike large-diameter pumps, however, small pumps are especially susceptible to bubbles in the pump's liquid channel, which results from the behavior of the two-phase interface during ground tests. Small pumps properly replicate micro-gravity bubble behavior in one-g, whereas large pumps allow fluid stratification. This project addresses a number of pump design modifications intended to increase the bubble tolerance of capillary pumps. In Phase I, promising pump design modifications will be integrated into small-diameter breadboard pumps which will be benchtested in parallel with standard pump designs. Phase II will make and test a cold plate containing several pumps of the modified pump design selected in Phase I. The performance of the new cold plate will be characterized in a large CPL during side-by-side tests with a cold plate containing conventional capillary pumps. Cold plate performance will be compared over a wide range of steady state and transient conditions.

Potential Commercial Applications: Capillary, two-phase heat transfer loops are baselined as the next generation of thermal control systems in large manned or unmanned space systems. Applications are emerging for communication satellites requiring heat rejection from a highly concentrated source to a remote radiator. CPLs can also be made flexible, permitting their use in two-phase radiators.

***

206 MSFC
92-1-09.09-4000 NAS08-39808
Low-Temperature, Stirling Cycle Refrigerator for Spacecraft Refrigeration Systems
Stirling Technology Company
2952 George Washington Way
Richland, WA 99352
Carl D. Beckett (509-375-4000)

A proof-of-principle design of an electrically driven Stirling cycle refrigerator will be developed to assist in refrigeration for manned spacecraft. The major advantages of this refrigeration system include modular capability, efficient operation over many heat rejection temperatures to minimize heat rejection requirements, elimination of fluid property temperature limits and zero-G fluid management problems present in conventional vapor compression systems, and flexible response to unexpected environmental conditions or spacecraft refrigeration system partial failures. The Stirling cycle refrigerator will also have low system-specific weight, simplified integration with spacecraft heat transport systems, and maintenance-free operation. The objectives of Phase I are to evaluate the concept's performance over a range of operating conditions, identify critical technology issues, select a target size and operating conditions, develop and optimize a conceptual design with an associated design layout making maximum use of existing technology, and project the device performance over the specified range of operating conditions. The design will be attractive for spacecraft refrigeration applications because of its effectiveness in a variety of operating conditions, and its high reliability, long life, and modular capability.

Potential Commercial Applications: The free-piston, Stirling cycle refrigerator technology has clear applications for other spacecraft applications such as cryogenic cooling of specialized sensors and instruments. Terrestrial application include freon-free refrigeration systems for conventional temperatures and biological, superconductive, and electronic cooling functions at lower temperatures.

***

207 JSC
92-1-09.10-0292 NAS09-18847
Real-Time, Graphical, Thermal-Fluid System Simulation
Cullimore & Ring Technologies, Inc.
49 Dawn Heath Circle
Littleton, CO 80127
Brent A. Cullimore (303-971-0292)

Thousands of pounds of cryogenic shuttle fuel were once inadvertently dumped into a Florida swamp because technicians monitoring the fluid transfer system were overwhelmed by a bewildering array of sensors and switches. An interactive, real-time, thermal-fluid system simulation tool could have helped the technicians both to trouble-shoot the operations ahead of time and to monitor their progress. Similarly, the design and testing of advanced spacecraft thermal transport loops is being hampered by the lack of such analysis tools. This project will develop a new class of computer simulation tools, improving upon current tools which still evidence their batch-style, mainframe origins. The new tools will both improve analysts productivity as they work with detailed simulations and enable the generation of real-time predictions to support test and ground operations.

Potential Commercial Applications: Resulting products will be immediately marketable because they fill a current void in the aerospace community. With slight modifications, these tools can be used in industries such as electronics packaging, energy, automotive, and architecture (HVAC).

***

208 JSC
92-1-09.10-2034 NAS09-18844
Carbon Brush Heat Exchanger
Energy Science Laboratories, Inc.
6888 Nancy Ridge Drive
San Diego, CA 92121-2232
Timothy R. Knowles (619-552-2034)

This project will investigate the use of carbon-fiber brush structures to enhance heat transfer between surfaces in vacuum. Short brush structures of suitable density are applied both to mating surfaces and for interpenetration when the surfaces are contacted, forming a large effective area heat exchanger. The extraction force required to separate the two brush surfaces is low, and the interface is reusable. Fibers are recommended that have desirable thermal and mechanical properties. The carbon brush heat exchanger also improves heat transfer at wet interfaces without the need for clamping. Phase I will focus on fabricating and testing sample fiber heat exchangers for thermal conductance. The project will also study the extraction force and degradation under separation-join cycling. Heat exchanger performance will be studied analytically and numerically to quantify potential benefits in external space thermal control systems.

Potential Commercial Applications: High-flux thermal interfaces reduce spacecraft payload temperatures and allow longer service life. Diverse power system interfaces would benefit batteries, radiators, and heat pipes. The brush interface has commercial application to energy, electronics, propulsion, and medical technologies.

***

209 JSC
92-1-09.10-6551A NAS09-18928
Passive, Modular, Heat-Driven Heat Pump for Lunar and Martian Explorations
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
Nelson J. Gernert (717-569-6551)

A self-contained, modular, passive, low-to-medium temperature, heat-driven, heat pump refrigerator will be developed for cooling components in a Lunar or Mars environment. The heat pump uses a gravity-assisted capillary pump loop, heat pipes, and "steam jet" ejector principles requiring no moving parts. Phase I will test the principle of the heat pump system. A non-optimized, scaled, proof-of-concept, heat-pipe heat pump will be tested to demonstrate the concept's feasibility. Estimates of performance show a 50°C lift, from 10°C to 60°C, is possible using lunar gravity and existing wick technology. A lift of 70°C could be achieved if existing wick pore radii can be reduced in size by a factor of 2. This passive, heat-driven, heat pump is effective, and using a capillary pump and "steam jet" ejector principles provides a reliable, compact system that is easy to operate and maintain. This heat pump concept provides a mechanism for rejecting heat during the lunar day. Improvements in wick pumping capability can also lead to overall reductions in main radiator sizes.

Potential Commercial Applications: A number of industries, such as steel, refineries, chemical, marine, and electrical utilities projects have waste heat that could be used to power air conditioning. This project's passive design may prove cost-effective for these applications, but an automobile air conditioning system powered from engine heat seems to be the most attractive commercial opportunity.

***

210 JSC
92-1-09.11-0700 NAS09-18845
Increased Lifetime Electroluminescence Phosphors
Implant Sciences Corporation
107 Audubon Road #5
Wakefield, MA 01880
Anthony J. Armini (617-246-0700)

Electroluminescent flat-panel displays are useful because they are lightweight, thin, and can generate their own light, thus permitting operation in ambient lighting conditions. A desirable goal is a color display which requires red, green, and blue phosphors. The best blue electroluminescence phosphor has exhibited inadequate lifetime, but no alternatives have been found. This project will investigate ion implantation techniques that can be used to counteract the factors leading to rapid aging.

Potential Commercial Applications: Flat-panel displays are currently one of the most important technologies for the next generation of information systems and computers. Full-color displays are required, but advances in phosphor lifetime must be made before the displays are practical.

***

211 JSC
92-1-09.11-9118 NAS09-18842
Field-Emitter Display Development for Workstations
Fed Corporation
P.O. Box 12802
Research Triangle Park, NC 27709
Gary W. Jones (919-781-6667)

The development of a new type of field-emitter-based display for NASA is the goal of this project. These field-emitter displays have the potential to provide high-resolution pixels, high brightness, full color, wide viewing angle, high energy efficiency, and low driver cost. They would be flat and possess small overall volume. The displays will be built from the company's unique, etched emitter tips with self-aligned gates. This workstation application will permit the level display devices to be designed to operate at high voltage levels,

approaching the level of CRTs, where high-efficiency phosphors are commonly available. High levels of emitter redundancy are coupled with vertical current flow through current limiting resistors. First, this project will develop a near-ideal workstation display for many applications, including those in space. Next, this project will demonstrate the feasibility of a process to improve yield, economy, reliability, and performance of field-emitter displays using etched emitters instead of evaporated emitters. The project would produce in Phase II a static, addressable array of pixels on a 50 mm x 50 mm field and would develop an over one million pixel usable video display.

Potential Commercial Applications: The display can be used in workstations, portable electronics, and other handheld instruments; avionics; control panels; virtual reality and/or three-dimensional, wall-hanging, high-definition television; projection TV; multimedia, printing, and other display, indicator or light panel applications.

***

212 JSC
92-1-09.12-7700 NAS09-18857
A Flexible, Artificial Intelligence Testbed
Nomadic Technologies
858 Lapara Avenue
Palo Alto, CA 94306
David Zhu (415-493-7700)

For future exploration missions, artificial intelligence (AI) will play an important role in the development of intelligent systems. However, because programming and experimenting with physical hardware is difficult, AI techniques are often developed using unrealistic and overly simplified assumptions. Consequently, there is a large gap between the AI theories and the envisioned applications of intelligent systems in space exploration. The nomadic, flexible, robotic, AI testbed presents a solution to bridge this gap by providing a fully-integrated robotic system with flexible hardware and software design, an adaptive robot simulator, and a library of robot reasoning and introspection functions. In addition to being a flexible AI testbed, the adaptive simulator provides a dynamic description of the robot and its environment so that the robot can modify this description using its introspective reasoning capabilities to improve its performance.

Potential Commercial Applications: Since the nomadic, flexible, robotic, AI testbed encourages the experimentation of a wide range of AI techniques on general purpose robotic system, the testbed will be an integral part of potential commercial applications that require intelligent motion capabilities.

***

213 JSC
92-1-09.13-3284 NAS09-18841
Polarization-Sensitive, Thermal Imaging Sensors
Physics Innovations, Inc.
3213 Evergreen Drive
St. Paul, MN 55121-1767
Cornell Chun (612-452-3284)

This project will develop a novel, polarization-sensitive, thermal imaging system. Polarization-sensitive thermal imaging has the following advantages over conventional imaging methods used in tracking systems: the new method senses the infrared thermal emissions of objects, operates without controlled lighting or in darkness, and can measure the degree of polarization and the angle of polarization for each image pixel. The degree and angle of polarization give the two angles that specify the local surface orientation of the object, from which information the object's shape and attitude can be determined. The polarization-sensitive, thermal imaging sensor is suitable for use in spacecraft tracking systems for rendezvous and proximity operations. Phase I will be a design study of specific polarizer and photodiode configurations. Design criteria for optimizing polarization-sensitive imaging performance will be determined for a range of operating conditions. Phase II will include the construction of a prototype system for polarization-sensitive imaging.

Potential Commercial Applications: These sensors can be used in a variety of applications including automated assembly; automated quality control; remote sensing of earth resources, agriculture, pollutants, and weather; area surveillance for police; intrusion detection; biomedical applications such as remote thermal imaging to detect cancer; search and/or track systems for detection and discrimination of aircraft and ballistic missiles; forward looking infrared sensors (FLIR); and night vision navigation.

***

214 LeRC
92-1-09.14-3088 NAS03-26915
Aeolian Tone Flow Meter Using Optical Fiber
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Lev Sadovnik (310-320-3088)

An innovative, vortex-shedding, optical-fiber flow meter will be developed. A single optical fiber passing through a flow-carrying pipe vibrates due to the natural phenomenon of vortex shedding. Information about the vibration, and thus the flow rate, is conveyed to monitoring stations. The measurement utilizes theoretically and experimentally proven linear relationship between the flow rate and the flow-induced vibration frequency of the vortex shedding body. Several candidate fiber sensor techniques will be investigated. With electronic signal processing, the accuracy of the flow rate measurement is expected to be 0.5%. This high ac-

curacy will allow early detection of gas leaks and increase the safety of space missions. Other advantages of the fiber sensor are its extremely low interference with gas flow, its high immunity to any electromagnetic field, and its ready integrability into gas monitoring systems.

Potential Commercial Applications: The success of this project may lead to a new class of compact, robust, optical-fiber flow meters for improved monitoring of various industrial processes and for use by gas utilities.

***

215 LeRC
92-1-09.14-7270 NAS03-26917
Electrochemical Compressor to Recover Hydrogen Boil-Off Gas from Cryogenic Tanks
Giner, Inc.
14 Spring Street
Waltham, MA 02154
Larry Swette (619-899-7270)

NASA has identified the need for high-efficiency, small compressors to compress the boil-off gas from cryogenic tanks from 34 to 70 kPa to greater than 7000 kPa. Hydrogen is of particular interest, and the design should minimize weight and power usage. An innovative concept developed by the company to meet the NASA requirement is a highly efficient, all-solid proton-exchange membrane, electrochemical, hydrogen compressor system containing no moving parts. Phase I will develop advanced components and concepts and show the feasibility of efficient performance of the resulting compressor at elevated pressures when combined with a regenerable water management system. In particular, this project will develop an efficient electrochemical cell that features a perfluorocarbon sulfonic acid membrane with bifunctional hydrogen electrode structures integrally bonded to each side of the membrane. Further, sealing concepts that allow 7000 kPa operation with no gas leakage will be investigated. The electrochemical hydrogen compressor cell and regenerative water management system developed in Phase I will ultimately be integrated into a recovery system for the boil-off gas from the hydrogen cryogenic tanks and adapted for use in spacecraft.

Potential Commercial Applications: The potential for commercialization of the hydrogen compressor system is excellent. It could be used as part of a system for cryogenic cooling or to recover hydrogen from diluted or contaminated streams such as outputs from gasifiers (Luirgi), biomass streams, and reformate streams. Special anode catalysts may be used when CO, H_2S, and certain hydrocarbons are present in the contaminated streams.

***

216 MSFC
92-1-09.15-2900 NAS08-39809
Cryogenic Quick-Disconnect Seals
Stress Engineering Services, Inc.
13800 Westfair East Drive
Houston, TX 77041-1101
S. Allen Fox (713-955-2900)

A reusable seal for cryogenic quick-disconnect connectors will be developed. To design the seal, this project will use knowledge gained from related applications, experience from prior test programs, application of finite-element analysis methods, and a test program. Finite-element analysis, combined with empirically derived relations for the flow of a fluid at a seal interface, will be used to verify that the seal designs satisfy the temperature, pressure, and leak requirements. This approach will demonstrate that the seal design is viable, manufacturable, and reusable and that the design process can be applied to related NASA and commercial programs.

Potential Commercial Applications: The seal can be used in liquification processes, firefighting, industrial and hazardous materials, advanced propulsion engines, advanced life support systems, and satellite servicing.

***

217 MSFC
92-1-09.15-3800 NAS08-39829
A Quick-Disconnect Cryogenic Joint
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
William E. Nutt (603-643-3800)

The goal of this project is the development of a quick-disconnect cryogenic joint that meets all of NASA's requirements: Helium leak rates less than 1.0 x 10^{-6} cc/s; 50 operating cycles over 5 years; withstand the environment at the NASA Kennedy Space Center and in space; and handle diameters of 10-15 cm, 350 kPa, and shuttle vibrations. The joint will incorporate a seal that, in smaller sizes and different joints, has proven leak-tight from ambient to superfluid helium temperatures at pressures ranging from vacuum to 2100 kPa. The overall objective is to demonstrate the feasibility of the quick-disconnect joint. The specific technical objectives are to demonstrate a joint, determine the feasibility of fabricating seals in the 10-15 cm range, and determine the vibration handling capabilities of the joint. A small, quick-disconnect joint will be designed, built, and tested to liquid helium temperatures. A fabrication technique for larger seals will be identified, and the vibration handling capabilities of the joint will be analyzed. A preliminary joint design for a NASA application will be developed. Phase I will demonstrate the feasibility of the joint.

Potential Commercial Applications: The quick-disconnect joint will have immediate applications wherever

cryogenic equipment is used or developed. MRI units, high energy physics, and super-conducting, electric energy storage rings are a few of the potential applications.

***

218 JPL
92-1-09.16-3800 NAS07-1207
High-Performance, Regenerative Sorption Compressor Element
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
William E. Nutt (603-643-3800)

A novel compressor element will be developed for fluid-loop regenerative sorption compressors which will improve the efficiency and reliability of the devices and reduce their mass and complexity. The project objectives are to demonstrate that the concept is feasible from thermodynamic, heat transfer, structural, material, and fabrication perspectives. Analyses will be conducted to demonstrate the feasibility of the first four perspectives, after which will follow the identification of a fabrication technique. When fully developed, the concept will be valuable to the sorption cooler technology development program at the NASA Jet Propulsion Laboratory and useful to space-borne cryocooler technology. It is anticipated that development of this concept will make sorption compressors the "compressor of choice" for many space applications.

Potential Commercial Applications: The primary application of the sorption compressor cartridge is in spaceborne cryogenic refrigeration systems. If sufficiently high efficiencies and low costs can be obtained, the technology may find applications wherever cryogenic equipment is used or proposed: MRI units, particle accelerators, magnetically levitated trains, superconducting energy storage devices, etc.

***

219 GSFC
92-1-09.17-3800 NAS05-32413
Miniature, Cryogenic Turboalternator
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Herbert Sixsmith (603-643-3800)

The company will develop a miniature, cryogenic turboalternator that will be an enabling technology for future low-power, vibration-free, space cryocoolers. The concept uses an alternator rotor incorporating a high-energy permanent magnet of uniquely simple construction and a novel ironless stator to absorb power from the cryogenic expansion turbine in a reverse Brayton cryocooler. Its advantage over more conventional turboexpanders is its avoidance of the parasitic heat leak from the room-temperature brake impeller typically used to absorb power from the turbine. Although this heat leak is of minimal importance in conventional reverse-Brayton cryocoolers designed for relatively high cooling loads, it is a major power penalty in the low-power instrument coolers that NASA needs for upcoming scientific space missions. By avoiding this heat leak, the turboalternator will enable vibration-free Brayton cycle machines to provide the same low-power advantage to these missions as the vibration-prone Stirling cycle machines currently in use.

Potential Commercial Applications: The result of this development will be a technology for miniature, high-speed electrical machines which offers both high reliability and high electrical efficiency with potential uses in specialty high-speed, low-power miniature motors for medical applications.

***

220 GSFC
92-1-09.17-4000 NAS05-32445
Integral Stirling and Joule-Thomson Cryocooler for Low Temperature Applications
Stirling Technology Company
2952 George Washington Way
Richland, WA 99352
L. Barry Penswick (509-375-4000)

The company will design a free-piston, Stirling cycle cryocooler demonstrator that will incorporate an integral gas compressor to provide a high pressure gas supply for a Joule-Thomson (JT) expansion valve. Pre-cooling of the JT working fluid will be performed by the Stirling cycle cryocooler. The integral Stirling and Joule-Thomson Cryocooler (SJTC) demonstrator will provide a nominal 0.2 watts capacity at 4.5 K. The SJTC will be innovative because it uses a Stirling cycle drive motor integrated with a gas compressor for the JT expander; it uses flexural bearings for non-contact operation of the Stirling cycle piston and displacer as well as the gas compressor pistons; it eliminates the need for lubricants; and it has the potential to demonstrate long life. The SJTC will employ components and technology spin-offs from the company's successful developments in long-life, domestic refrigeration system, and low-temperature spacecraft cryocoolers. Phase I will focus on the design of a SJTC demonstrator. Phase II includes the fabrication, assembly, and performance testing of the SJTC.

Potential Commercial Applications: This low-temperature refrigeration system is ideally suited for applications where long, maintenance-free operating life and good cooling performance are required. These applications include medical diagnostics and imaging systems, superconducting sensors, and the cooling of advanced computer components or superconducting motors.

***

221 GSFC
92-1-09.17-7351 NAS05-32414
Adaptive Vibration Suppression Mount for Cryogenic Coolers
CSA Engineering, Inc.
2850 West Bayshore Road
Palo Alto, CA 94303-3843
Eric M. Austin (415-494-7351)

Cryocoolers produce vibration levels that cause unacceptable jitter of infrared sensors. This movement leads to reduced performance because of increased line-of-sight jitter. These harmful forces, should, therefore, be suppressed before they reach sensitive components. The traditional method, passive isolation, relies on soft mounts between the disturbance machinery and the structure. However, isolators have low mount stiffness which leads to problems such as static misalignment, increased travel requirements, and decreased mount strength. This project will develop an innovative mounting system for cryocoolers–specifically, mounts with adaptively-tuned dynamic compliance characteristics and high static stiffness. Using a combination of piezoceramics and passive isolators, the hardmounts will be designed to be stiff at all frequencies except the discrete disturbance frequencies of the cryocooler at which point the mounts will be soft. This system will effectively isolate the structure from the disturbances without the problems that traditional isolators cause. The Phase II "adaptive hardmount" will be able to track changes in the disturbance frequencies and adjust the "notches" in the stiffness to follow these changes. The adaptive hardmount will be lightweight, have no moving parts, and will require very little power to operate.

Potential Commercial Applications: The "adaptive hardmount" will solve many vibration isolation problems that cannot be solved with available techniques. Near-term commercial markets are likely to be found in performance-driven applications: machinery such as cryocoolers and control moment gyros in spacecraft; machinery for submarines, torpedoes and other naval vessels; turbines and gearboxes in aircraft and helicopters; and equipment for making computer chips.

***

222 GSFC
92-1-09.18-6100 NAS05-32416
Compact, Real-Time Sensor for Non-Volatile Residues
Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303
Douglas J. Bamford (415-493-6100)

Non-volatile residues that have harmful effects on the performance of optical elements in space are difficult to detect and control. Current techniques yield no information about the identity of the contaminants and are too slow to provide real-time information. This project will develop a compact, inexpensive sensor based on diode laser technology to provide species-specific information about contaminants in real time. Phase I will measure the performance of a device based on this concept. If Phase I is successful, the design of the sensor will be optimized, and a prototype will be constructed during Phase II for delivery to NASA. The information provided by this sensor will allow NASA personnel to identify and eliminate sources of contamination on spacecraft.

Potential Commercial Applications: The sensor's main application will be monitoring contaminants in clean rooms used in manufacturing such as the semiconductor industry.

***

223 GSFC
92-1-09.19-1522 NAS05-32436
Man-Machine Interaction Models for Advanced Spacecraft and Robotic Applications
Photon Research Association, Inc.
1033 Massachusetts Avenue
Cambridge, MA 02138
James D. Turner (617-354-1522)

This project consists of two major parts. First, the Human-Machine-Task-Computer-Aided-Design (HMT-CAD) software, a NASA SBIR product, will be upgraded with advanced multibody dynamics modeling capabilities for analyzing surface contact interactions such as rolling, sliding, and penetration. This capability is required for biodynamic simulations of musculoskeletal systems (e.g., bone-cartilage-bone interactions at joints, design of prosthetics), operator-object contact and manipulation (e.g., analysis of a hand holding a tool), robotic-object contact and manipulation (e.g., analysis of docking, berthing, grasping, and seating), and cybernetics (e.g., using contractile jells as artificial muscle). Second, this project will take control design approaches for mechanical systems and apply them to both recently developed general systems performance models (GSPT) and task optimization strategies developed for mimicking human capabilities. These methodologies are useful when applications have redundant ways to accomplish a task.

Potential Commercial Applications: The upgraded HMT-CAD product will permit NASA to study the consequences of machine design alternatives relative to the performance of both the machine and the operator. This product will be broadly useful for mechanical designs or performance assessments that require interactions between industrial, biodynamic, clinical, and rehabilitation applications.

***

224 MSFC
92-1-09.20-0003 NAS08-39810
Evaluation of Plume Impingement Effects
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
George E. Caledonia (508-689-0003)

Spacecraft thrusters and vents send gas streams of various species onto spacecraft surfaces and can either directly or indirectly cause localized heating and contamination. This project will build a test facility that uses a laser breakdown technique to produce supersonic and hypersonic beams of species combinations which simulate anticipated exhaust species. This device will also evaluate surface interactions between exhaust species and spacecraft materials. These beams could be composed of individual species or full exhaust simulations so that individual and collective effects on surfaces can be evaluated. A range of velocities between 2 to 5 km/s should be achievable for molecular species of interest. Phase I will construct and characterize two beam sources for several gases (CO, H_2, and N_2H_4/NH_3) and demonstrate a heating measurement on one surface. Phase II will evaluate how plume and vent species interact with specific spacecraft surfaces, and will provide NASA with a quantitative data base for the design and analysis of future space vehicles.

Potential Commercial Applications: The device would have general use in the aerospace community as a test facility to evaluate materials for space applications. There is also some potential for applying this technology to harden and/or modify materials.

***

225 MSFC
92-1-09.20-8581 NAS08-39830
Measurements of Gas-Surface Interactions from Plume Constituents on Spacecraft Surfaces
Remtech, Inc.
3304 Westmill Drive
Huntsville, AL 35805
Eugene C. Knox (205-536-8581)

The project will measure plume impingement gas-surface interactions (GSI) for current and new exterior coatings so that safe rendezvous can be assured with Space Station Freedom (SSF). Currently, these measurements have not been taken for surfaces used on spacecraft, and the firm's prior work has illustrated the extreme sensitivity of the momentum exchange between a surface and an impinging gas. The measurements will be obtained in the NASA Marshal Space Flight Center's low-density flow chamber, where a thruster, like those used on vehicles docking with SSF, will impinge on surfaces typical of the space station exterior. The impingement force will be measured over a range of impact angles for several representative surfaces and coatings. Phase I will develop the test plan, and Phase II will execute it. Results will be installed into an existing program for computing the GSI effects of plume impingement on SSF.

Potential Commercial Applications: Potential commercial applications are a gas/surface interaction data base for space-certified materials, a material certification laboratory, microbalance fabrication, gas/surface interaction control coatings, and a revised GSI code.

***

226 GSFC
92-1-09.21-3400 NAS05-32449
A System for the Control of Balloon-Lifting Gas Temperature
Winzen International, Inc.
12001 Boulevard, Suite 200
San Antonio, TX 78249
Thomas M. Lew (512-690-3400)

To improve the performance of zero-pressure stratospheric balloons, this project addresses the need that a radiating curtain be installed in the balloon. The curtain will be designed and positioned so that it extracts heat from the lifting gas during the daytime and radiates this heat externally to the balloon. The curtain will be deactivated at night. Depending on the curtain's efficiency, the daytime heating and venting of the lifting gas will be reduced or eliminated, thereby reducing or eliminating the need for night ballast drop and allowing the maintenance of a constant altitude. Using less or no ballast permits longer missions and/or increased payload.

Potential Commercial Applications: Enhanced balloon performance should result in longer and more stable missions that will result in more valuable scientific data with greater commercial potential.

***

10: Space Power

227 LeRC
92-1-10.01-3200 NAS03-26405
Lightweight Graphite-Aluminum Space Radiators for Thermal Management
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Uday Kashalikar (617-890-3200)

Graphite-fiber-reinforced metal matrix composites (MMC) are well suited for space radiator applications because of their high specific thermal conductivity, stiffness, and excellent resistance to space environment. The objective of Phase I will be to demonstrate the feasibility of pressure casting a lightweight graphite-aluminum (Gr-Al) structural radiator panel with a built-in metallic heat pipe. The weight will be reduced by using a corrugated-radiator-panel design that provides the

requisite flexural stiffness without the weight penalty of a honeycomb core. The high thermal conductivity of the MMC material (over 3 times that of aluminum) will enable a radiator panel with a 250 percent improvement in the specific power dissipation capability while meeting structural characteristics of the baseline aluminum sandwich component. Additionally, the heat pipe will be cast in place, thereby eliminating a separate joining operation. The corrugations will increase effective emissivity of the panel, producing further performance enhancement. During Phase I, Gr-Al corrugated panel specimens with a built-in metallic pipe will be fabricated to net shape using a low cost pressure casting process developed by the company. Test results on these specimens will be used to project performance improvements for a baseline radiator component. Phase II will optimize the designs and processes and demonstrate the reproducibility of high thermomechanical properties in the resulting components.

Potential Commercial Applications: Commercial applications for this high-performance material exist in ultra-high-power density electronic circuits, uncooled automotive and aircraft engine components, and several thermal management applications in mining and oil drilling equipment and in nuclear power plants.

***

228 LeRC
92-1-10.01-4000A NAS03-26722
Multi-Hundred-Watt, Stirling Technology Demonstrator for Space Power
Stirling Technology Company
2952 George Washington Way
Richland, WA 99352
Brad A. Ross (509-375-4000)

A free-piston, linear alternator Stirling power convertor will be designed that will demonstrate the technology needed for a dynamic isotope power system (DIPS) with a nominal end-of-mission output of 500 watts. The multi-hundred-watt Stirling technology demonstrator (MSTD) will be innovative for many reasons, including its use of flexural bearings for noncontacting operation of the piston and displacer, the lack of gas springs and center ports in a Stirling convertor, the radiative coupling of the Stirling convertor heater head to the heat source, and the system's potentially long life. The MSTD will be a spin-off of the company's successful development of technology used for a 300-watt domestic refrigerator. Phase I will design the MSTD and Phase II will assemble and shake-out testing of the MSTD and Phase III will test the endurance of the MSTD.

Potential Commercial Applications: This novel energy conversion concept is ideally suited for applications where the high efficiency, reliability, and uniform performance, of a DIPS has high priority. These applications include space power systems and some remote terrestrial power systems.

***

229 LeRC
92-1-10.02-1795 NAS03-26908
Indium-Phosphide Solar Cells Grown on Zinc-Selenide-Coated Silicon Substrates
Matrix Science, Inc.
2952 George Washington Way
Richland, WA 99352
F. William Addis (509-375-1795)

This project investigates the use of zinc-selenide (ZnSe) buffer layers for growing highly efficient indium-phosphide (InP) cells on silicon. Prior experimental results indicate that the ZnSe interlayer for InP films grown on ZnSe-coated silicon substrates may reduce the dislocation density below $10^6/cm^2$ in the InP films. The objective of Phase I will be to deposit low-defect-density InP films on ZnSe-coated Si substrates to establish the feasibility of using ZnSe buffer layers to grow highly efficient InP cells on silicon. After developing an approach for growing InP on ZnSe-Si substrates, the InP films will be characterized with respect to dislocation density and minority carrier properties. Metal-organic chemical vapor deposition (MOCVD) growth of ZnSe and InP will be done at Washington State University. Phase I will be structured into four tasks: MOCVD growth of $In_{0.53}Ga_{0.47}As$ on ZnSe-coated silicon; MOCVD growth of InP on ZnSe-coated silicon; electro-optical characterization; and physical characterization. The primary objective of the tasks is to demonstrate the feasibility of fabricating highly efficient InP cells on ZnSe-coated silicon substrates. Phase II would focus on the growth of highly efficient InP cells on silicon substrates with ZnSe buffer layers.

Potential Commercial Applications: InP solar cells are being considered as a source of electrical power for space terrestrial applications. This project could also have spin-off applications in optoelectronics.

***

230 LeRC
92-1-10.02-5992 NAS03-26909
Thirty-Percent-Efficient, Tandem Solar Cell String for a Line-Focus Photovoltaic Concentrator Array
JX Crystals
4617 174th Place, SE
Issaquah, WA 98027
Mark Kuryla (206-643-5992)

NASA has previously sponsored ENTECH, Inc., to develop a photovoltaic concentrator array using a point focus lens and a 30-percent-efficient tandem cell-stack, with our firm supplying the GaSb wafers used in those cell-stacks. An experimental array that uses the firm's material and this new technology will be launched into

orbit this fall as part of the PASP+ program. This point-focus design suffers from two drawbacks: the domed lens is difficult to manufacture, and the array requires two-axis tracking. ENTECH believes these two problems can be overcome by using a line-focus Fresnel lens. However, a line-focus lens operates at low concentration and does not leave room for the tandem-cell leads. This project will develop a line-focus, tandem-cell receiver assembly using an optical secondary that simultaneously increases the concentration ratio, provides room for the tandem-cell leads, and provides for radiation shielding. The objective of Phase I is to design and fabricate the first line-focus tandem cell receiver. Once a developed receiver is combined with ENTECH's new lens, a high-performance, low-cost module will become available to space power array suppliers.

Potential Commercial Applications: The low-cost, line-focus tandem concentrator module will have very high power density and specific power, and it will be radiation resistant. It can be used by NASA for power upgrade on Space Station Freedom, by DOD in high radiation orbits, or on commercial satellites.

***

231 JPL
92-1-10.03-3800 NAS07-1216
Micromachined Evaporator for Wicked AMTEC Cells
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Christopher J. Crowley (603-643-3800)

An evaporator component that completely eliminates the need for electro-magnetic (EM) pumps in the alkali-metal, thermal-to-electric conversion (AMTEC) cells being developed by NASA Jet Propulsion Laboratory will be investigated. AMTEC power conversion is attractive with radioisotope power sources at 1100 K because of its high conversion efficiency, low mass, modularity, and redundancy. AMTEC and a general purpose heat source will operate at conversion efficiencies greater than 20 percent, thereby increasing specific power by a factor of three compared with present thermoelectric converter designs. Currently, the EM pump component presents potential problems for cell reliability because of freezing and thawing, physical blockage by contamination, or vapor lock. This project will research a stable, mechanical, micromachined evaporator which should experience a long life unlike porous sintered wicks. The micromachined structure has small capillary size (4 μm radius) so it can achieve the operating pressures for high temperatures (≅ 1100 K) that result in high AMTEC conversion efficiencies and eliminate the need for an EM pump. Porous sintered wicks, however, are limited to lower pressures and temperatures. Phase I will experimentally demonstrate the feasibility of using sodium to make a high-head capillary evaporator. Phase II will complete the development by building a working AMTEC cell and demonstrating its operation.

Potential Commercial Applications: Compatibility of AMTEC power conversion with a wide variety of heat sources makes AMTEC attractive for NASA, DOE, Air Force, and SDIO space missions or for terrestrial applications with combustion systems, vehicle propulsion, or silent power conversion for submarines.

***

232 JPL
92-1-10.03-5992 NAS07-1237
Thermophotovoltaic Devices for High-Efficiency Thermal-to-Electric Conversion
JX Crystals
4617 174th Place, SE
Issaquah, WA 98027
Peter Gruenbaum (206-643-5992)

Radioisotopes have been used as a source of energy for space applications where there is insufficient solar energy to use standard photovoltaic arrays. Boosting the efficiency of these systems is possible by using a thermophotovoltaic (TPV) system where the radioisotope heats a radiator, which in turn emits infrared photons. Photovoltaic cells then absorb these photons and convert them into electrical power. This project will assemble an innovative thermophotovoltaic cell string using gallium antimonide (GaSb) cells which will convert infrared light at wavelengths as long as 1.8 microns and reflect the rest back onto the radiator. Calculations using measurements of existing GaSb cells show an energy conversion efficiency as high as 28 percent for a 1000°C temperature radiator. Several new design features will be developed in making this TPV cell string.

Potential Commercial Applications: GaSb cell strings can be used in radioisotope thermoelectric generators that are converted into TPV generators for higher efficiency. Applications for terrestrial, gas-burning TPV generators as small, quiet, lightweight electric power supplies for remote locations are possible.

***

233 LeRC
92-1-10.05-3260 NAS03-26906
Advanced Electrode Materials for Silver-Metal-Hydride Batteries
EMEC Consultants
R.D. 3 Roundtop Road
Export, PA 15632
Rudolf Keller (412-325-3260)

Advances in energy density and in the life of rechargeable storage systems are sought for space and other applications. This project will explore the performance of novel metal-hydride electrodes for their incorporation into silver-metal-hydride cells. Plate compositions containing various rare earth components will be developed. The development of a high-performance cell for space application is targeted, but the information will

also be valuable in efforts to replace nickel-cadmium cells.

Potential Commercial Applications: This project will encourage the replacement of silver-zinc batteries with advanced batteries that have increased cycle life and better storage capabilities.

***

234 JPL
92-1-10.06-1100 NAS07-1218
Lithium-Ion Rechargeable Battery System with Sulfur-Dioxide-Based Electrolyte
Yardney Technical Products, Inc.
82 Mechanic Street
Pawcatuck, CT 06379
Sohrab Hossain (203-599-1100)

The introduction of carbonaceous material as anode in the development of rechargeable lithium batteries (Li-ion technology) is a major breakthrough because of the system's excellent cycle life, energy density, and safety characteristics. The present state-of-the-art of Li-ion systems, however, exhibits low rate capability and high self-discharge characteristics (12 percent per month). This project will investigate $S0_2$-based electrolytes in the Li-ion system in order to improve performance. The investigation will be carried out in an experimental electrochemical cell with suitable carbonaceous anode, a cathode using lithiated transition metal oxides ($LiCoO_2$ or $LiNiO_2$), and SO_2-based $LiAlCl_4$ electrolyte.

Potential Commercial Applications: The anticipated improvements in rate capability and self-discharge behavior will make Li-ion battery systems more attractive than Ni-Cd and Pb-acid systems for various commercial applications.

***

235 JPL
92-1-10.06-7565B NAS07-1223
Novel Polymer Electrolytes for Lithium Rechargeable Batteries
Moltech Corporation
Engineering Building-SUNY
Stony Brook, NY 11794-2800
Terje Skotheim (516-632-7565)

The technology for efficient and economical generation and storage of electrical power should be improved. To further this objective, new solid polymer electrolytes are needed to advance a broad class of electrochemical energy systems. Polymer electrolytes have a relatively low ion mobility at room temperature, thereby necessitating operation at elevated temperatures. The project's specific technical objective is to synthesize new solid polymer electrolytes with high cationic conductivity at room temperature. In particular, the project will focus on the design of highly dissociated salts that can be incorporated into polymer gel electrolytes to produce high cationic conductivity. Another approach to enhance the cationic conductivity will be the covalent attachment of highly delocalized anion groups to a flexible polymer backbone (single-ion conductor).

Potential Commercial Applications: The successful development of highly conductive polymer gel electrolytes will provide solid polymer electrolytes for a variety of thin film electrochemical devices, such as advanced rechargeable batteries with long life and high energy storage capacity.

***

236 GSFC
92-1-10.07-1750 NAS05-32435
High-Energy-Density, Nickel-Metal-Hydride Batteries
Ovonic Battery Company
1826 Northwood Drive
Troy, MI 48084
Srini Venkatesan (313-362-1750)

This project will demonstrate the performance characteristics of a high-energy-density, rechargeable battery based on the nickel-metal-hydride system with an energy density of 70 Wh/Kg and over 200 Wh/l. These values are almost three times that of a lead-acid and more than two times that of a nickel-cadmium system. Nickel-metal-hydride batteries, under development by the firm for some time, have demonstrated good energy density, easy manufacturability, and environmentally benign disposition. By utilizing some of the new high-specific-capacity, metal-hydride-alloy negative electrodes and new lightweight positive electrodes, the project will fabricate and test prismatic starved cells of greater than 5 Ah, yielding 70 Wh/Kg in gravimetric energy density and more than 200 Wh/l in volumetric energy density. The cells will be tested for capacity, rate capability, and temperature performance. Phase II will make and test many individual prismatic, starved cells. Once reproducible results are obtained, Phase II will make and test battery modules using these individual cells.

Potential Commercial Applications: This technology can be used on earth in portable computers, cordless power tools, cellular telephones, walkie-talkie radios, medical appliances, household battery-operated appliances, toys, and portable c.d. players. These batteries will be useful to equipment manufacturers and designers who have sought long-running and high-powered cordless power sources.

***

237 GSFC
92-1-10.07-1980 NAS05-32430
A Novel, Negative, Hydride Electrode for Nickel-Metal-Hydride Batteries
Materials & Electrochemical Research
7960 South Kolb Road
Tucson, AZ 85706
R.O. Loutfy (602-574-1980)

The newly discovered C_{60} carbon material exhibits unique electrochemical and physical properties. By vapor deposition and dry pressing, this project will make C_{60} and catalyzed C_{60} electrodes for hydrogen storage and supplies. These electrodes will be fully characterized as hydrogen electrodes in a nickel-hydride battery concept. The research will establish the nature of the electrochemical hydrogenation and dehydrogenation of C_{60} as a function of environmental conditions. A single cell will also be examined for its efficiency self-discharge, and charge and discharge characteristics, which will establish the viability of a low-cost, lightweight, high-power-density, secondary battery for aerospace applications.

Potential Commercial Applications: Preliminary results indicate that C_{60} electrodes could be used to store energy which could be used for secondary batteries and fuel cells. This concept could lead to a new class of secondary batteries and to other electrochemical systems for energy storage and generation.

***

238 JSC
92-1-10.08-1100A NAS09-18846
High-Energy-Density, Rechargeable, Nickel-Zinc Cells with Improved Cycle Life
Yardney Technical Products, Inc.
82 Mechanic Street
Pawcatuck, CT 06379
Robert Hellen (203-599-1100)

This project focuses on improving the cycle life of nickel-zinc cells. The objective will be to develop an electro-permeable membrane (EPM) that, together with a novel electrolyte developed at Lawrence Berkely Laboratory, will control the shape change of the zinc plate. Zinc electrodes and two types of separators will be coated with the electro-chemical membrane. Sixteen cells will be built to determine the effect of the EPM. Half of the cells will be filled with the novel electrolyte, while the other half will be filled with 3% KOH. The cells will be characterized and then cycled at a 100 percent depth of discharge to failure. The test data will be analyzed, and a final report summarizing the results will be submitted.

Potential Commercial Applications: In addition to potential use for electric vehicles, nickel-zinc cells with improved cycle life would provide manufacturers of portable-computers, power tools, and electronic equipment with a cost-effective alternative to nickel-cadmium and/or nickel-metal-hydride cells.

***

239 JSC
92-1-10.08-2699 NAS09-18860
Safe, High Energy Aqueous Batteries for Manned Applications
Electrochimica Corporation
2487 Spring Street
Redwood City, CA 94063
M. Eisenberg (415-369-2699)

Manned space activities require high-energy, portable, rechargeable batteries for cameras, tools, instrumentation, and back-packs. These batteries must be absolutely safe and resist abuse because they come into direct contact with space station crews. As a developer of high-energy electrochemical systems, including several patented lithium systems, the firm believes that no lithium rechargeable system will be available for at least 5 to 10 years. The next choice among safe, aqueous batteries is the stabilized, long-cycle-life, nickel-zinc system with an energy density range of 55-84 Wh/Kg and 125-200 Wh/l, using conventional or new, lightweight composite nickel plates. The high-rate and power capabilities and long cycle life cf 600-1000 deep cycles have been verified in numerous government tests on large vented cells. The goal of this project will be to redesign this system to completely seal the units as required for the aerospace environment. In the laboratory, this approach has already been shown to be feasible. The detailed work plan consists of the initial development of cells at two capacity levels (2 Ah and 4-10 Ah) in 4-cell modules and the electrochemical evaluation of all pertinent aspects.

Potential Commercial Applications: Sealed cells and batteries with projected high-energy density capabilities would find numerous applications in military and commercial communications, in portable instrumentation, computers, communication, and consumer electronics, as well as in electric vehicles.

***

240 LeRC
92-1-10.09-7501 NAS03-26907
Electrically Conductive, Atomic Oxygen Protective Coatings for Space Power Systems
J.A. Woollam Company
650 J Street, Suite 39
Lincoln, NE 68508
Duane E. Meyer (402-477-7501)

Spacecraft charging, thermal management, and atomic oxygen (AO) degradation are spacecraft problems that are usually independently addressed. The goal of this project will be to demonstrate the effectiveness of coatings which simultaneously conduct electric charge and heat and resist the atomic oxygen

degradation that occurs in the low earth orbit (LEO) environment. Three candidate materials will be investigated: indium-tin-oxide (ITO); titanium-nitride (TiN); and ruthenium-dioxide (RuO_2). ITO is a well-known, transparent conducting oxide used in display technologies, but little is known about using ITU in space. TiN is used for interconnects in microelectronics and is a better electrical conductor than even pure Ti metal (nitrides are known to resist oxidation). RuO_2 is a metal with good electrical conduction and an oxide that should resist further oxidation in the LEO environment.

Potential Commercial Applications: Protective coatings, especially those resisting oxidation and corrosion, have enormous commercial uses. The coating developed on this project will have improved thermal conduction, electrical conduction, and environmental stability.

***

241 JPL
92-1-10.10-8443 NAS07-1225
Planar, Integrated-Magnetic Power Components
E/J Bloom Association, Inc.
115 Duran Drive
San Rafael, CA 94903-2317
Gordon E. Bloom (415-492-8443)

In space, power-supply subsystems are needed that have high power-processing densities and low product profiles. New core and winding geometries for the magnetic components of these subsystems have been developed to match the specifications for use in space. These innovations include the use of both rigid and flexible printed-circuit methods for windings, matrix arrays of miniature toroidal cores, as well as various "flattened" magnetic core shapes. Another proven technique to reduce the volume and weight of the magnetic content of power converters is the design art of integrated-magnetics. with this design, only one magnetic core structure is needed for a multiplicity of transformer and inductive functions of a power converter circuit. The goal of this project is to develop new methods so that planar-magnetic design concepts can be blended and extended with integrated-magnetic design approaches to obtain superior magnetic components for power applications. The project will also make and test sample magnetic components to verify the design methods.

Potential Commercial Applications: Applications are possible in any electronic power-processing product requiring low-profile, cost-effective, and high-density power magnetic components such as an AC-DC or DC-DC power supply.

***

242 LeRC
92-1-10.11-3383 NAS03-26721
High-Efficiency, Proton-Exchange-Membrane Fuel Cell for Near-Ambient Operation
Electrochem, Inc.
400 West Cummings Park
Woburn, MA 01801
Brian Morriseau (617-932-3383)

Due to a combination of membrane resistance, limited catalyst utilization, hydration, and pressure and temperature requirements, fuel cells based on conventional proton exchange membranes (PEMs) have yet to achieve their full potential as compact, efficient, lightweight power supplies for aerospace and terrestrial application. Recent research has shown that the catalyst loading can be decreased by two orders of magnitude with relatively little effect on performance. Further improvement in the ionic-electronic interface combined with newly available PEM materials will result in a simple, low-cost, high-performance fuel cell that will operate at ambient conditions with virtually no ancillary equipment. This project will prepare several types of advanced membrane-electrode assemblies, incorporating newly available ultra-thin perfluorosulfonic (PFSA) membranes and a high-conductivity solubilized PFSA ionomer, and test them in fuel cells for performance at near-ambient conditions. The decreased complexity will result in a system with higher power density, greater reliability, smaller volume, and improved operational flexibility than previously available for aerospace, satellite, and Mars and Lunar missions.

Potential Commercial Applications: The advanced, near-ambient-operating solid polymer fuel cells developed in this program will replace batteries and power generators in such applications as military and civilian aerospace, backup power sources, field generators, remote power, and non-polluting vehicles.

***

243 HQ
92-1-10.11-9450 NASW-4788
Near-Ambient Solid-Polymer Fuel Cell
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Gerhard L. Holleck (617-769-9450)

All fuel cells, particularly polymer-electrolyte-membrane fuel cells, are extremely attractive for space and earth applications because of their high-energy conversion efficiency. This project will develop a solid polymer fuel cell that can efficiently operate at near-ambient temperatures without ancillary components for humidification and/or pressurization of the fuel or oxidant gases. This fuel cell will be made with a novel, integrated-catalyst, proton-exchange polymer unit that has no interfacial barriers so that water diffusion from the cathode to the anode will not be impeded. The catalysts for both electrodes will be electro-precipitated

in a highly dispersed form within the proton exchange membrane in close proximity to the gas-polymer interface. This fuel cell will offer significant gains in weight and volume power density. It will reduce complexity and make fuel cells attractive for smaller and portable power supplies which at present, is not feasible because the fuel cell stack is a vital but only small part of the total system.

Potential Commercial Applications: Near-ambient, solid-polymer fuel cells extend fuel cell technology to small units making it suitable for remote distributed power, marine power, power tools, computers, video cameras, rovers, and automated sampling equipment.

***

11: Space Propulsion

244 MSFC
92-1-11.01-0660 NAS08-39807
A Fast Algorithm for Transient All-Speed Flows and Finite-Rate Chemistry
Engineering Sciences, Inc.
4920 Corporate Drive, Suite K
Huntsville, AL 35805
Yen-Sen Chen (205-721-0660)

A novel algorithm derived from a pressure-based methodology will be developed to improve the calculation of time-accurate chemically reacting flows at all speeds. The algorithm will combine the non-iterative strong coupling between fluid-dynamics and chemistry with a penalty function within a fast, stiff, ordinary differential equation solver to speed up convergence. The operator-splitting technique is used to derive the non-iterative, strong coupling, predictor and corrector procedure. Sensitivity and parametric studies will be carried out for one-dimensional and multi-dimensional flame propagation flows in low-speed and high-speed situations to assess and verify this unified algorithm. If this algorithm is valid, it will result in more efficient and stable computational fluid dynamics (CFD tools that include other propulsion-related physics such as atomization, spray, and turbulence. This algorithm can be used to create more reliable designs and to perform diagnostic analyses of rocket-engine flow fields.

Potential Commercial Applications: A validated, highly efficient algorithm, that can be incorporated into any CFD code utilizing pressure-based methodologies to create a more efficient and more reliable CFD design and diagnostic tool, can be expected from this study.

***

245 MSFC
92-1-11.01-2008A NAS08-39811
Radiation-Convection Coupling In Rocket Motor and Plume Analysis
Seca, Inc.
3311 Bob Wallace Avenue, Suite 202
Huntsville, AL 35805
Richard C. Farmer (205-534-2008)

A coupled radiation-convection analysis utilizing state-of-the-art computational fluid dynamic (CFD) flow solvers will be developed to accurately describe main-chamber and plume radiation for chemical and nuclear rocket. Despite several decades of intensive research in rocket plume radiation analysis, both thermal environments and infrared (IR) signatures are still modeled with an uncoupled simulation. First, the flow field is predicted, and then the radiation is predicted from the thermal, pressure, and species fields but without accounting for the radiated energy losses in the flow field solutions. Even inside the rocket motor, the radiation to the motor walls is only crudely approximated. Currently, radiative transport is not adequately treated in any of the CFD solvers used for rocket propulsion system analysis. This project will apply the modified differential approximation in various forms, which represent specific propellant systems, to solve the radiative equation of transfer in order to fully couple the radiation and convection in a CFD code.

Potential Commercial Applications: The radiation-convection-coupled CFD analysis will provide a new design tool to improve the simulation of chemical and nuclear rocket motors, coal-fired power plants, and other industrial processes. All of these uses have potential for commercial applications of the new code.

***

246 MSFC
92-1-11.02-0003 NAS08-39838
Optical Diagnostics for Solid Rocket Motor Nozzles
Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810
Evan R. Pugh (508-689-0003)

The radiative and convective heating experienced by materials in solid rocket motor nozzles has been inferred from plume radiation measurements and from the measured thermal response of nozzle materials. Nevertheless, the heating loads within nozzles are still not well understood. This project will develop an optical diagnostic method for the direct measurement of the temperature of the combustion products within the nozzle and the radiative heating experienced by interior nozzle surfaces. This radiometric diagnostic could also measure the thermal response of nozzle material close to the nozzle throat. The successful application of this diagnostic could provide NASA with experimental verification of solid rocket motor design codes and an ability to optimize and calibrate experimentally the solid

rocket motor simulators currently under development by NASA.

Potential Commercial Applications: These diagnostic techniques could produce valuable new instrumentation for the rocket motor industry and would aid the development of future high-performance rocket motors.

***

247 MSFC
92-1-11.02-4747 NAS08-39831
Low-Cost Analysis Tool for Concurrent Engineering Applications

Huntsville Sciences Corporation
150-102 West Park Loop
Huntsville, AL 35806
James V. McAnally (205-830-4747)

The development of a low-cost, simple-to-use software package to construct geometric models and grids for concurrent engineering analysis applications is the goal of this project. The software package will consist of an interactive CAD program to construct the geometric model, an unstructured finite-element grid generator to develop the computational grid network, a post processing color graphics package for displaying the results, and interface software which restructures the grid and sets up the required boundary conditions for SINDA, TRASYS, and ANSYS computer programs. The tool will be structured for an engineering workstation with a UNIX operating system. Each software module in the analysis package can be run in an independent mode; however, each module will be linked with menus to permit interactive sequential runs of the individual codes. The user will have the option to construct a geometric model with CAD, compute a finite-element grid network for the model, and compute structural temperature distributions using the grid network with the finite-element thermal analyzer (FEHEAT) or transform the grid for SINDA application using a finite-element to finite-difference translator. The user can also output the surface grid for a TRASYS radiation analysis, or interpolate structural temperatures computed with either FEHEAT or SINDA onto an ANSYS grid for structural analysis. Operation codes will be restricted to only those developed by the company.

Potential Commercial Applications: This tool can be used in spacecraft and launch vehicle thermal, propulsion, and environmental control system design; power generation system design; electronic component design and packaging; automobile engine cooling, lubrication, and hydraulic systems; HVAC systems; and fire protection systems.

***

248 MSFC
92-1-11.02-6576 NAS08-39812
Virtual Design Tools for Thermo-Fluid Analysis of Liquid Rocket Engine Thrust Chambers

CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
Yong Lai (205-536-6576)

Modern thermo-fluid design methodology of rocket engines involves several computational components including CAD/CAM, CFD, thermal-analysis, structural analysis, and data visualization tools. These components are strongly interlinked through boundary conditions, grids, and property data. Nevertheless, engineers find that they use the components in a stand-alone form or by manual interfacing via external files. A novel, virtual design tool linking the codes with object oriented programming will be developed to allow individual codes to evolve without affecting their interaction. The key components, the CFD REFLEQS code and thermal SINDA code, will be coupled, thereby allowing their simultaneous execution. An innovative, multi-domain, multi-media capability will be implemented in the REFLEQS code. One-to-one, one-to-many, and arbitrary match grid among different domains will allow different grid topologies in different domains so that structural, thermal, and CFD codes (e.g. ANSYS, SINDA, and REFLEQS) can interchange data. In Phase I, the design tool will be verified on a 40 K engine and demonstrated on the STME configuration. In Phase II, the code will be extended to allow simultaneous analysis of two-dimensional and/or three-dimensional configurations by using an advanced distributed-shared memory approach.

Potential Commercial Applications: This approach will find extensive use in the prediction of thermo-fluid phenomena in liquid rocket engines, in automotive engine cooling, and in heat exchanger design.

***

249 MSFC
92-1-11.03-0660 NAS08-39832
Comprehensive Model for Combustion Instability in Liquid Propellant Rocket Engines

Engineering Sciences, Inc.
4920 Corporate Drive, Suite K
Huntsville, AL 35805
Yongmo Kim (205-721-0660)

This project will develop a comprehensive model for simulating the combustion instability in the liquid propellant rocket engine. The linear and nonlinear analytical solution for the three-dimensional chamber wave phenomena will be used to validate the numerical model. The approach will study the overall behavior of nonlinear combustion instabilities; effects of acoustic oscillations on subcritical and supercritical vaporization and combustion process in stable and unstable engine operating conditions; and oscillating flow fields and

liquid-fuel trajectories during combustion instability. The successful completion of Phase I will provide a reliable numerical model for the combustion instability analysis as well as information about the effects of various design parameters, fluid dynamics interplay, atomization, vaporization, and turbulent mixing.

Potential Commercial Applications: A validated comprehensive model will serve as a design aid and a diagnostic tool to resolve the combustion instability problems in actual liquid propellant rocket engines or gas turbine combustors and to optimize the combustor design.

***

250 MSFC
92-1-11.03-4770 NAS08-39839
Mixing Efficiency Diagnostic Using Spectroscopic Analysis
Spectral Sciences, Inc.
99 South Bedford Street, #7
Burlington, MA 01803-5169
Michael Gersh (617-273-4770)

Development of efficient rocket engines requires a technique to measure their mixing and combustion efficiency, both for assessing the efficiency of specific engines and for evaluating computer models of propellant mixing and combustion. The objective of this project is to develop a mixing efficiency diagnostic using a spectroscopic analysis (MEDUSA) instrument that can quantitatively measure the results of incomplete mixing in rocket engines. This process uses a novel, diode-laser absorption spectroscopy technique to measure the spatial distribution of acetylene and oxygen at the rocket nozzle exit plane. This is a relevant measurement since these species are characteristic of the low and high oxidizer-to-fuel ratio regions of the plume flow field that result from incomplete mixing and combustion. Such spatial mapping of the nozzle exit plane has not previously been achieved. Phase I will demonstrate the feasibility of developing a MEDUSA instrument by understanding the few residual uncertainties concerning the utilization of the laser, the absorption by C_2H_2, and the possible spectral interferences from other plume species. These experimental results would then facilitate the development of the MEDUSA in Phase II.

Potential Commercial Applications: Commercial uses include optimizing commercially developed rockets and analyzing rocket plume radiation data. In addition, there is a possible market for the optimization of large combustion sources for power generation and industrial uses.

***

251 MSFC
92-1-11.03-6576 NAS08-39813
Acoustic Interactions with Spray Combustion in Liquid Propellant Rocket Thrust Chambers
CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
Maciej Pindera (205-536-6576)

Combustion instabilities in liquid rocket motors result from complex, transient, nonlinear interactions between gas flow, pressure waves, and processes associated with heat release. Recent developments in numerical technology, allow for viable simulations of these interactions. The current numerical models for combustion instability, however, do not make use of available highly accurate schemes. This project will develop a high accuracy numerical model capable of resolving nonlinear interactions among liquid fuel sprays, fluid dynamics, and chemistry, and understanding their effects on combustion instabilities in the rocket motor environment. Phase I will concentrate on the coupling between spray characteristics and droplet transport, using simple chemistry in a two-and three-dimensional compressible flow field. After the flow field has been calculated using highly accurate TVD or Godunov schemes, it will be tested and made available at the company. Spray physics will include a correlation type spray model coupled to existing unsteady droplet evaporation and Lagrangian tracking algorithms. Simulations will be performed to study the response of combustion to different spray configurations. This research will result in an advanced multi-dimensional combustion instability code that can be used by NASA to design future rocket thrust chambers and predict combustion stability limits.

Potential Commercial Applications: This project will produce an advanced numerical methodology for studies of nonlinear combustion instabilities in liquid rocket engines. The developed computer code will be of interest to all injection spray designers and rocket chamber manufacturers where accurate simulations of acoustically coupled flow transients is of paramount importance.

***

252 MSFC
92-1-11.04-1756 NAS08-39814
Improved Temperature Measurement in Composite Material for Aerospace Applications
Analysis & Measurement Services Corporation
AMS 9111 Cross Park Drive, NW
Knoxville, TN 37923-4599
H.M. Hashemian (615-691-1756)

In developing composite materials for aerospace applications, the thermostructural material behavior is of paramount importance. Efforts to measure temperature variations within this material, during rapid transients when stresses may be critical, have been hampered by the uncertainties in the thermal bond between the

thermocouples and the material. To date, no method is available to evaluate the quality of a thermocouple installation in a solid material. Consequently, it is not possible to determine how well the output of a bonded or embedded thermocouple actually represents the temperature of the surrounding material under transient conditions. Neither is it possible to determine the extent to which the transient outputs of separate thermocouples are different due to actual existing material temperature differences as opposed to differences in the integrity of the installations. This project will develop technology to measure the integrity of a thermocouple installation so that the actual response time of the thermocouple can be identified and used for correction of transient temperature data.

Potential Commercial Applications: The technology to be developed will be useful to NASA, the U.S. Air Force, and for all scientific and industrial applications that require timely temperature measurements for process control, safety, or efficiency, such as the steel industry, the chemical industry, and industrial manufacturing processes.

***

253 MSFC
92-1-11.04-3200 NAS08-39844
High Reliability, Low-Cost RTM Preforms for Solid Rocket Motor Nozzles
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Glenn Freitas (617-890-3200)

Solid rocket motor (SRM) nozzles are currently fabricated by wrapping a compliant bias (+/-45°), carbon-phenolic prepreg tape. Because conventional weaving looms cannot produce bias fabrics, nozzle manufacturers must procure dry standard 0°-90° fabric, slit short strips along the bias direction, and sew them together to form a continuous tape. This process is labor intensive, has a high scrap factor, and produces a tape with substantial variability. Furthermore, this construction often leads to quality problems during the subsequent prepregging operation. This project will adapt the company's unique textile process–flat braiding–to produce continuous lengths of bias tape of consistent quality. The dry tape is wound directly onto a male nozzle tool to produce the desired "shingled" preform architecture. The lay-up is then placed in a female resin transfer mold (RTM) for infusion with phenolic resin. This method should yield consistent quality (no stitches, no edge quality problems) at a lower cost (less fabric handling, no prepregging). In Phase I, machinery will be modified to produce continuous bias tape. The tape will be wound onto a tool supplied by Thiokol, Inc., who will also produce a demonstration article. Phase II will involve machine scale-up to support manufacturing methods development for full-scale SRM nozzles.

Potential Commercial Applications: The textile technology may be applied to any composites application, RTM or otherwise, where fiber orientations other than 0° or 90° are desired. These may include aircraft components, automotive parts, and sporting goods.

***

254 MSFC
92-1-11.04-4015 NAS08-39840
Non-Destructive Evaluation of Solid Rocket Motor Liners, Insulators, and Propellants
Quantum Magnetics, Inc.
11578 Sorrento Valley Road, Suite 30
San Diego, CA 92121
Lowell J. Burnett (619-481-4015)

Recent test results have shown that it is feasible to use nuclear magnetic resonance (NMR) to monitor liner thickness and state-of-cure during fabrication of large, composite-case, solid rocket motors (SRMs). In addition, these results indicate that NMR will provide useful information regarding propellant uniformity, the presence of contaminants, and the state-of-cure of the insulation layer. However, these results are not directly applicable to steel-case SRMs since the presence of the case will distort both the RF and the steady magnetic fields needed for measuring the NMR. In addition, the liner, insulation, and propellant materials used in steel-case SRMs are not identical to those used in composite-case SRMs. This project will develop a prototype NMR system to determine thickness and state-of-cure of the SRM liner for both steel-case and composite-case SRMs. The NMR system will also be capable of determining the insulator state-of-cure and identifying local regions of contamination in both the liner and insulator. In addition, it should be possible to use this NMR system, with suitable modifications, to monitor propellant uniformity at specific points in the fabrication process.

Potential Commercial Applications: Using composites, laminates, and composite-metal hybrids for fabrication is becoming increasingly important in the commercial sector. The NMR technology will be readily applicable to many commercial fabrication and assembly processes where nondestructive inspection and nondestructive evaluation of individual components are required.

***

255 MSFC
92-1-11.04-8900B NAS08-39833
Effective Porosity of Rayon-Based Carbon-Phenolics
PDA Engineering
2975 Redhill Avenue
Costa Mesa, CA 92626
Douglas A. Marx (714-540-8900)

The effect of pore pressures resulting from the pyrolytic decomposition of carbon-phenolics is to add an internal force on the solid phase of the remaining char.

The effective porosity represents a measure of the area over which this pore pressure acts as well as defining the area of the solid phase material over which internal stresses are developed to counteract the pore pressure. Tests have demonstrated that volume porosity is a poor measure of the effective porosity. Also, in the presence of confining boundary conditions, the effective porosity can vary greatly due to the compressibility of the solid phase. In order to perform precise thermostructural calculations of stresses and strains, as well as accurate predictions of structural margins of safety, both the magnitude of the pore pressure and the effective porosity must be known. To date, laboratory data have failed to isolate these two parameters from each other. Therefore, the intent of this study is to design a test specimen that will accurately measure the effective porosity in precharred specimens of carbon-phenolic. This design test will be developed by performing thermostructural analyses and a limited amount of experimental testing. The project's main goal is to derive a test methodology suitable for rayon-based carbon-phenolics. In addition, the project will research how variations in pore morphology influence the effective porosity.

Potential Commercial Applications: A means to significantly increase the reliability of carbon-phenolic rocket nozzle structural components will be of particular value to NASA and to the rocket nozzle industry that must contend with maintaining a high degree of reliability and performance.

***

256 LeRC
92-1-11.05-4707 NAS03-26918
Improved Electroformed Structural Copper and Copper Alloys for Rocket Components
Electroformed Nickel, Inc.
283 Winfield Circle
Corona, CA 91720
Glenn Malone (714-371-4707)

Because of high thermal conductivity requirements, OFHC (oxygen-free, high-conductivity) copper and certain copper alloys are primarily used as the liner materials for regeneratively cooled rocket engines. Unfortunately, the wrought alloys and electroformed pure metal do not exhibit the structural strengths of electroformed nickel or wrought nickel alloys having less than desired thermal conductivity. This project offers a new way to improve the "as deposited" structural properties of a pure, electroformed OFHC equivalent. Preliminary test results have indicated that unusually high yield strengths in copper can be obtained (while maintaining low oxygen content) using less conventional deposition techniques. Once the optimum deposit parameters and deposition current manipulation cycles are established, further enhancement of yield strength (with suitable ductility) may be obtained by minor alloying and/or dispersion strengthening through co-deposition so that these improved properties are retained over a fairly wide thermal range and stress-strain cycling service.

Potential Commercial Applications: This material can be used for rocket engine thrust chambers, barrier layers for prevention of hydrogen embrittlement, high-performance heat exchangers subject to high coolant pressures, and high-energy eximer laser components. A possible military application is for anti-armor-shaped charge devices.

***

257 HQ
92-1-11.06-1992B NASW-4789
Metalized-Cryogen for Advanced Hybrid Engines
Orbital Technologies Corporation
402 Gammon Place, Suite 10
Madison, WI 53719
Eric E. Rice (608-833-1992)

An innovative, metalized, hybrid solid rocket motor will be developed. While many approaches to solid propellant delivery to a combustion chamber have been investigated, in general, these devices are complex, heavy, and expensive. This project will couple two areas of propellant enhancement: propellant metalization and cryogen solidification. Because the performance enhancement capability of metalized propellants has received much study since the 1960s, the system simplifications associated with solid cryogens are both promising and attractive. Phase I will demonstrate the basic metalized-cryogen solidification process. Phase II will build and fire a small motor in the 100-200 lb thrust range.

Potential Commercial Applications: The hybrid engine may be adaptable to thrust ranges from 20 lb to 20,000 lb or higher and may operate at chamber pressures of 200 to 400 psia. Smaller sizes may operate as pulse thrusters for attitude and velocity trim. Larger sizes would be suited to upper-stage applications and space tug uses. The engine's major strengths are its simplicity, long-term space storage, and low-cost reliability without complex metalized propellant delivery systems.

***

258 LeRC
92-1-11.06-5888 NAS03-26919
Engine Design and Testing of Metalized Propellants
Truax Engineering, Inc.
5925 Farnsworth Court
Carlsbad, CA 92008
Andrejs Vanags (619-931-5888)

This project will test the performance of LOx/RP1-A1 propellants in rocket engines that have an innovative stage combustion chamber and improved chamber and nozzle contouring. To this end, injector and engine designs will be generated during Phase I. The flow properties of the metalized fuel will also be investigated.

Potential Commercial Applications: Metalized propellants will improve the performance of pressure-fed sounding rockets and rocket boosters.

***

259 LeRC
92-1-11.06-9500 NAS03-26914
Enhanced Fuel Burning Rate in Hybrid Chemical Rockets
Aerodyne Research, Inc.
45 Manning Road
Billerica, MA 01821
David B. Stickler (508-663-9500)

The low mass burning rate of solid fuel constrains the engineering design and application of hybrid rockets. This project will synthesize and conduct burn-rate tests of a modified solid fuel that will establish and maintain a prescribed high level of surface roughness as it regresses. A hydrodynamically rough wall results in substantially enhanced net heat flux to the fuel surface and a correspondingly higher fuel burn rate. Phase I will experimentally demonstrate this process, with the overall objective of retaining the inherent safety, low cost, and controllability of hybrids, while simplifying rocket engine design, lowering hardware cost, and providing a much higher burn-rate than is achievable with homogeneous fuel grains. Phase I will emphasize fuel synthesis, burn rate experiments, data analysis, and projection of performance gains for real, full-scale hybrid rocket engines. A fuel burn-rate improvement of at least a factor of two is anticipated without compromising safety or fuel cost.

Potential Commercial Applications: Hybrid rocket engine technology is currently being developed for commercial implementation. The fuel modification demonstrated in this project will encourage hardware simplification and better performance, thereby improving the commercial potential of this rocket engine technology. NASA applications include lower-cost, next-generation launch vehicles that can be used in man-rated systems.

***

260 MSFC
92-1-11.07-2246 NAS08-39822
Grid Optimization Tools for Complex Structural Models
Alabama Research
7809 Doubletree Lane
Huntsville, AL 35802
Lawrence W. Spradley (205-883-2246)

Computer software for optimizing finite-element grids used in complex structural models will be developed. The grid optimization tools will operate directly on existing models from standard industry and government codes. The new software will extend existing packages and will act as a stand-alone processor to optimize, remesh, and perform special functions and then replace the grid on a compatible file for reprocessing by the finite element package. The result will be a higher quality grid that has a more accurate and reliable stress analysis and vehicle component design. By using the automatic optimizer code, NASA can conduct more accurate structural analyses and introduce special functions such as flaws, holes, and weld misalignment. Phase I will test and verify the grid optimizer tools by using two-dimensional models and theories. Extension of the methods to three dimensions will be investigated. Phase II will further extend the software to three-dimensional tetrahedral and hexahedral grids. A comprehensive test problem set will then be selected in conjunction with NASA and the results analyzed and compared to previous solutions and test data. Phase II will end when the software and documentation is delivered to NASA.

Potential Commercial Applications: The grid optimization tool will be used by aerospace, mechanical, and civil engineers in all disciplines who design high-rise buildings, analyze damaged buildings, perform fatigue analyses of commercial airplanes, design bridge structures, and perform safety analyses of dams, bridges, highways, and automobiles.

***

261 LeRC
92-1-11.08-9450 NAS03-26916
Modulation of Solar Momentum for Satellite Attitude Control
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
James D. Klein (617-769-9450)

A non-chemical and non-mechanical means of achieving attitude control of satellites is the goal of this project. Even the relatively low thrusts required for attitude control eventually deplete stored chemical propulsion fuels and limit the operational lifetime of satellites. This project will develop with electrically tunable optical properties that allow active control of momentum transfer with the solar radiation and provide attitude control without propulsion fuels or moving parts. The resulting low-thrust propulsion system will provide reliable, low-power attitude control using materials suitable for long-term operation in the space environment. Both commercial and defense satellites could realize enhanced lifetimes and greater reliability from the use of a non-chemical and non-mechanical attitude control and stationkeeping system. Phase I seeks to demonstrate the necessary spectral and thermal performance in a thin-film prototype panel. More advanced switching mechanisms, spectral enhancements, and scale-up technology would be developed in Phase II.

Potential Commercial Applications: The successful development of non-mechanical solar momentum control systems for spacecraft will have commercial

application in communications, meteorological, and scientific research satellites.

***

262 JSC
92-1-11.09-0236 NAS09-18840
Small Composite Combustion Chambers
Ultramet
12173 Montague Street
Pacoima, CA 91331
Robert H. Tuffias (818-899-0236)

Under NASA support, the company has developed iridium-rhenium (Ir-Re) technology that has demonstrated the ability of liquid rocket engines to operate above 2200°C for tens of hours. Units having thrust ratings of 22N and 445N have been built and tested and have demonstrated an improvement in specific impulse /of some 20 seconds, which translates into a productivity increase of 5-10 percent. Phase I will demonstrate the feasibility of fabricating the next-generation small combustion chamber through the application of composite structures.

Potential Commercial Applications: Upper-stage rocket engines are typically regeneratively cooled, resulting in a large performance penalty and high launch loads. This Ir-Re technology applied to launching communications satellites could save $2-to-4 million per launch.

***

263 JSC
92-1-11.09-5911 NAS09-18872
Lightweight, Oxidation Resistant, High-Temperature Composite Thrusters
Fiber Materials, Inc.
5 Morin Street
Biddeford, ME 04005-4497
Clifford F. Baker (207-282-5911)

An advanced thruster is needed that can meet the high-temperature, weight-sensitive applications of modern satellite propulsion systems. A composite structure, manufactured using low-density materials such as carbon fibers encased in a ceramic matrix, can provide thrusters that meet these requirements. The choice of ceramic matrix will define the operating temperature of the composite and the type of propellent which can be burned. Using very-high-temperature ceramic materials will result in thrusters able to withstand flame temperatures of 2700°C, thereby precluding the need for active cooling of the nozzle and eliminating a complex manufacturing step. Ceramic materials will also reduce manufacturing costs and improve system reliability by eliminating a possible failure point.

Potential Commercial Applications: The resulting composite thrusters will benefit boost motors and attitude control thrusters on commercial communications satellites. These materials may also find applications as nozzle materials for other high temperature environments such as furnace nozzles and plasma nozzles.

***

264 JPL
92-1-11.10-3772 NAS07-1235
An Inertial Electrostatic Confinement Power Source for Electric Propulsion
Rockford Technology Association, Inc.
912 West Armory
Champaign, IL 61821
Heinrich Hora (217-333-3772)

Experimental studies of a unique, inertial electrostatic confinement (IEC) fusion concept will be conducted. The IEC concept has the potential to generate a high power-to-weight ratio power supply for electric propulsion during deep space missions. Phase I will use existing equipment to carry out a proof-of-principle experiment which, if successful, will define the design basis for more rapid testing in Phase II. IEC involves the injection of ions and electrons in a spherical configuration arranged so that ions are trapped into a potential well, giving a high fusion reaction rate in a small "core" region in the center. The inertia of the injected ions combined with the internal potential well provide the necessary confinement. Since magnets and laser drivers are not involved, this system offers a much higher specific power than conventional fusion approaches. The IEC concept was originally addressed in the 1950s by Farnsworth, but since then the concept has received little attention. The present version relies on improved operation under special, pulsed, high-current injection and preliminary experiments with lower currents using this configuration have been quite encouraging. Since the concept results in beam-beam reactions, it is ideally suited for burning advanced fusion fuels like D-^{3}He, which in turn, allows for the use of direct conversion of the fusion energy to a high voltage output, offering very efficient coupling to an advanced electric propulsion unit.

Potential Commercial Applications: The lightweight, high-power IEC system will enable future deep space missions. Many commercial applications may develop, especially spinoffs for terrestrial uses which require a high-power density.

***

265 JPL
92-1-11.10-6551A NAS07-1224
Porous Cathode for Alkali Propellant MPD Thrusters
Thermacore, Inc.
780 Eden Road
Lancaster, PA 17601
William G. Anderson (717-569-6551)

This project will develop a porous cathode that will eliminate cathode erosion as the mission-limiting factor of alkali propellant MPD thrusters. A porous cathode

delivers lithium directly to the cathode tip, lowering the effective work function of the cathode surface. During start-up, the arc spots vaporize the lithium instead of heating and vaporizing tungsten. During steady state, the increased lithium concentration near the surface increases backscatter and reduces tungsten evaporation.

Potential Commercial Applications: If successful, this concept will remove cathode erosion as a factor for limiting the duration of space missions.

***

12: Human Habitability and Biology in Space

266 JSC
92-1-12.01-5090A NAS09-18830
A Methodological Approach to Improving Pre-Flight Adaptation Training
Essex Corporation
1040 Woodcock Road, Suite 227
Orlando, FL 32803
Robert S. Kennedy (407-894-5090)

NASA is currently employing a pre-flight adaptation trainer (PAT) to pre-adapt astronauts to conditions that cause space motion sickness (SMS). This project will develop an approach that will aid in enhancing the fidelity and effectiveness of this device and its associated training regimens. Specifically, the project will develop a "profile analysis" technique so that a direct comparison of the pattern of SMS symptoms experienced aloft and after re-entry can be made with the pattern obtained in the PAT. The project will also develop a video-based measurement technique to provide quantitative information concerning the nature of the visual stimulus delivered to trainees in the PAT. This two-phase methodology will help modify the fidelity of the PAT configuration and will aid in verifying the effectiveness of training received in the PAT. This effort will also produce a biocybernetic video measurement technique that can be applied to other space flight simulation and virtual environment systems in which measurement of the visual stimulus for motion and orientation is important.

Potential Commercial Applications: The availability of an automated system that links visual display parameters (flow and edge rate, pitch and roll rate, etc.) with the magnitude of the perceptual experience can be used to provide engineering specifications for all manner of virtual reality systems, whether they are used for training or recreation.

***

267 JSC
92-1-12.01-8492 NAS09-18867
Compact, Digital, Flash X-Ray Imager for Quantitative Physiological Studies in Space Vehicles
Advanced Optical Technologies, Inc.
141 Davis Road
Storrs, CT 06268
Yong-Sheng Chao (203-429-8492)

Continuous and progressive bone loss is a major health hazard in prolonged manned-space flight. Internal body organs, especially the heart, lungs, and blood vessels of brain, also experience complicated adaptations to weightlessness. Therefore, systematic research is necessary to understand these adaptations and to identify possible countermeasures. An accurate, fully automated, dual-energy, digital, flash x-ray imaging system will be developed for the quantitative monitoring of bone mineral content (BMC) and for anatomical imaging of the internal body organs of humans or animals in space. A recently developed, large format (8" x 11"), integrated, amorphous-silicon, photodiode array is used with most efficient scintillators (CsI(Tl) and BGO) for energy-selective, x-ray image detection. The novel x-ray imager is designed to have its key imaging quality parameters comparable with those of computed radiography. The imager has an accuracy of better than 1 percent in BMC determination and can ensure distinctive separation of bone and internal body organs for monitoring physiological change under weightless conditions. A compact, flash x-ray source with microsecond pulse-width, synchronized with the selected action of the imaged objects, will precisely find the imaged object without requiring the immobilization of animals in space vehicles.

Potential Commercial Applications: This device can be used in the clinical diagnosis of osteoporosis and in portable x-ray imaging.

***

268 JSC
92-1-12.01-9357 NAS09-18864
System for Rapid Detection of Microbial Contamination in Water
New Horizons Diagnostics
9110 Red Branch Road
Columbia, MD 21045
Marjorie Wier (410-992-9354)

Rapid, simple methods for detection of microbial contamination of water are needed to replace the tedious and complex standard culture methodology. Systems based on detection of microbial ATP through the bioluminescent reaction of luciferin-luciferase have been developed. However, of these systems has been hampered by the instability of luciferin and by the complexity of the instrumentation used to measure for light emission. To overcome these problems, the company has developed unique methods of immobi-

lizing and stabilizing luciferin-luciferase in a solid phase format, including a hand-held photo-multiplier-tube-based luminometer capable of very sensitive measurement of emitted light. This project will use these technologies to devise a system which detects microbial contamination of water samples. The system will be based on a filter unit with a port for insertable cards holding glass fiber filters. Once the sample is processed, the card can be inserted into the luminometer for measurement. Especially during space flight, this system offers an easy-to-use and sensitive method to measure microbial contamination. The method can also be extended to measure microbial contamination on surfaces, in food, and in the air.

Potential Commercial Applications: This system can be used for rapid clinical testing for urinary tract infections, bacteria in cerebral spinal fluid, and in peritoneal fluid from peritoneal dialysis patents, other possible applications will be in the food industry testing for microbial contamination of processed beverages, milk, and prepared foods; the industrial, quality control monitoring of sanitation processes and clean room processes; and in environmental monitoring for bacterial load in drinking water and at remediation sites.

***

269 JSC
92-1-12.02-2484 NAS09-18851
Sensor Performance Enhancements for Process-Control, Water-Quality Monitor for Space Application
Astro International Corporation
100 Park Avenue
League City, TX 77573
E.L. Jeffers (713-332-2484)

The firm is developing a process-control, water-quality monitor (PCWQM) for the Space Station Freedom, which measures the potable water supply's temperature, conductivity, pH, iodine, and total organic carbon content. The baseline design contains conventional technology pH probes as limited life items. Newly developed ion-selective, field effect transistor (ISFET) pH probes could improve pH sensor life, reliability, maintainability, and accuracy and enhance performance during long duration missions. The baseline PCWQM design does not require turbidity measurement. Turbidity, however, measures process water total dissolved solids and is useful in detecting breakdown of water processor ion-exchange bed or filter. This proposal has two objectives: 1) determine the feasibility of using ISFET technology to improve pH measurement, and 2) determine the feasibility of using compact, low-power, nephelometer-based, solid-state, electro-optical technology to measure turbidity.

Potential Commercial Applications: The process-control, water-quality monitor can be used for aqueous cleaning solvents and ultrapure water, agricultural sensors, real-time blood monitoring, and oceanographic monitoring.

***

270 JSC
92-1-12.02-7770 NAS09-18863
Microwave Sterilizable Access Port
Umpqua Research Company
P.O. Box 791, 125 Volunteer Way
Myrtle Creek, OR 97457-0118
James E. Atwater (503-863-7770)

A reliable means is needed to access biologically sensitive systems, including the ECLSS water stream and flight experiments. The ability to aseptically remove samples and products, as well as to add materials to sterile or susceptible systems, has always been compromised by the lack of a reliable means of sterilizing the mating fixtures. The microwave sterilizable access port consists of three subsystems: an in-line valve-port assembly, a portable microwave sterilization chamber, and external hardware such as a sample container or connection to another sterile system. Before and after the systems being connected, microwave energy is used to sterilize all mating surfaces. The systems are joined by the combined use of microwave transparent materials and geometries that permit exposure to all desired surfaces. This project will present designs and prepare an extensive bibliography on the use of microwaves to sterilize contaminated surfaces.

Potential Commercial Applications: In addition to NASA, the Centers for Disease Control, and military laboratories, the microwave sterilizable access port will be readily adapted to meet the needs of the semiconductor, food processing, and pharmaceutical industries.

***

271 JSC
92-1-12.02-7831 NAS09-18862
Portable Fiber-Optic Particulate Monitor
Research International, Inc.
18706 142nd Avenue NE
Woodinville, WA 98072
Elric W. Saaski (206-486-7831)

The goal of this project is the development of a hand-held, fiber-optic-based monitor to survey for high concentrations of airborne, organic, or inorganic particulate debris. The device will be based on the collection and ratiometric detection of diffractively scattered light from suspended material and will use Fourier optics in combination with optical fibers to provide high sensitivity and small overall size. This project will test the capacity of sensing-head optical output to be converted to an equivalent particulate concentration by a microcontroller-based electronics package that provides an liquid crystal display (LCD) read-out, and, as needed, serial-digital-transfer of the data to a mainframe computer. On-board memory will maintain a moving data window or will be

set to store events that meet certain criteria, thereby allowing the user to later review and permanently record significant readings.

Potential Commercial Applications: This hand-held device could be the basis for a "smart" smoke detector or could be used as a personal data logger that monitors the dust inhalation by miners or others working in dirty, potentially hostile environments.

***

272 JSC
92-1-12.02-9806 NAS09-18837
Fourier-Transform Infrared Instrumentation for Analysis of Organic Contamination in Water Supplies
Advanced Fuel Research, Inc.
P.O. Box 380379
East Hartford, CT 06138-0379
Chad M. Nelson (203-528-9806)

Current practice relies on laboratory analysis for quantifying organics in water supplies. However, this analysis is time-consuming and leads to possible changes in the sample during handling. A system is needed that can directly measure the concentration of organics down to parts-per-billion levels, thereby allowing continuous monitoring of water quality. A fast response time would help prevent unacceptable levels of contamination from reaching the potable water supply. This project will develop a water monitoring system that uses attenuated total reflectance-Fourier-transform-infrared (ATR-FTIR) spectroscopy. FTIR can simultaneously and rapidly quantify many different contaminants. Since water is highly absorbing in the infrared, direct absorption measurements are impossible. Therefore, aqueous analysis requires using internal reflection, which yields an extremely short pathlength. Phase I will consider two different materials for the internal reflection elements (IREs) with surface modifications to enhance low-level detectability limits. To increase the sensitivity, the surface of the IRE will be modified to increase hydrophobicity and/or surface area available for absorption. The goal of this project (Phase I and Phase II) is to develop an instrument that will rapidly monitor aqueous systems for hydrocarbon contamination.

Potential Commercial Applications: This project may result in two commercial products: a rugged instrument for continuous monitoring of organic contamination in water; and a new IRE for detecting trace amounts of organics in highly absorbing liquids and gases.

***

273 ARC
92-1-12.03-0778 NAS02-13777
Non-Invasive Assessment of Exercise Metabolic Responses by Analysis of Sweat Lactate
Sudormed, Inc.
12341 Newport Avenue, Suite D-200
Santa Ana, CA 92705
Don Schoendorfer (714-730-0078)

In order to measure non-invasively the effectiveness of ground-based and space exercise regimens, this project will investigate the lactic acid content in human sweat as an effective measure of maximal aerobic power. The firm has a sweat "Patch" specimen container which can continuously and non-invasively monitor individual lactate levels for one week. Phase I will explore the effectiveness of lactate monitoring in sweat as a predictor of the lactate profile in blood. Phase II will extend the levels of exercise performed and the categories of individuals monitored. Phase II could also include space studies during extended (i.e., greater than 15-day) missions.

Potential Commercial Applications: The most obvious commercial application would be the general health and fitness market where individuals could monitor themselves and establish performance profiles. In addition, remote care facilities could use the device to monitor long-term patient metabolic rates.

***

274 ARC
92-1-12.04-1297 NAS02-13774
Direct Osmotic Concentration of Waste Water
Osmotek, Inc.
P.O. Box 1882
Corvallis, OR 97339
Edward G. Beaudry (503-753-1297)

This project will demonstrate the feasibility of using, as a pretreatment, a direct-osmosis technology to concentrate raw waste water models. This pre-treatment can improve the performances of other treatment processes, such as electrodialysis, by reducing secondary treatment volumes and increasing conductivity. This project will evaluate membrane and osmotic agent performance over an extended time period. This concentration technique requires no phase change, has minimal energy and space requirements, and no expendables. Fouling limitations of other membrane techniques make them unsuitable.

Potential Commercial Applications: This technology can be used in waste treatment, biomedical protein purification, and in food processing.

***

275 MSFC
92-1-12.04-1483 NAS08-39841
Electrochemical Oxidation of Organic Materials by the Excited States of Metal Surfaces
Interfacial Sciences, Inc.
2362 Walsh Avenue
Santa Clara, CA 95051
Karl W. Frese, Jr. (408-492-1483)

This project concerns utilizing the excited states on a metal surface to accelerate the oxidation of organic materials. The novel catalyst consists of a highly doped semiconductor covered with a layer of metal such as Pt or Ag. The semiconductor property is required so that electronic holes in the underlying semiconductor layer may be injected into the metal film or small metal catalyst particle. Following injection into the metal film, the holes are transported ballistically and arrive at the metal electrolyte interface at an energy below the Fermi level of the metal. When such holes reach the metal electrolyte interface, their energetic state represents an excited state of the metal surface and, as such, they should possess high reactivity towards oxidation of organic molecules such as alcohols and acids. When optimized, the resulting electrocatalyst will be used to oxidize organic compounds at enhanced rates with less poisoning by strongly bound intermediates. The choice of metal layer will determine the product. For Pt layers, complete combustion is expected, giving CO_2.

Potential Commercial Applications: If successful, this project would improve the energy efficiency and lifetime of electrodes used for electrochemical combustion of organic materials. The research would open the possibility of direct fuel cells without reforming. Energy savings would be realized because the electrocatalyst would operate at lower overpotential. With these improved features, the market for electrochemical devices would expand.

***

276 JSC
92-1-12.04-2228A NAS09-18929
Water Treatment by a Pervaporation Removal of Gas and Volatile Organic Compounds
Membrane Technology & Research, Inc.
1360 Willow Road, Suite 103
Menlo Park, CA 94025
Richard W. Baker (415-328-2228)

Dissolved ammonia, air, and volatile organic compounds (VOCs) interfere with the performance of current water reclamation systems developed for space mission applications. Pervaporation is a compact, energy-efficient technology that is able to remove these troublesome contaminants from a water stream, producing small, concentrated waste streams. Phase I will evaluate existing membranes and modules with model streams containing the dissolved gases and VOCs. Based on these results, a preliminary design of a system suitable for a space application will be prepared. The performance of this system and how it might best be integrated into a complete water reclamation process will be addressed. In Phase II, a proof-of-concept system based on the design will be built and demonstrated.

Potential Commercial Applications: Pervaporation of the removal of VOCs from water is already at the pre-commercialization stage. This project would provide data relevant to additional applications such as the de-aeration of boiler feed water and the removal of ammonia, sulphur dioxide, and hydrogen sulfide from industrial waste streams.

***

277 JSC
92-1-12.04-2852 NAS09-18843
Water Polishing by Directional Freeze Crystallization
Polar Spring Corporation
3501 Edison Way
Menlo Park, CA 94025
William M. Conlon (415-368-2852)

Future human planetary exploration and habitation require the development of closed systems for recycling water. Present methods of water reclamation use expendable membranes, cleaning agents and acids, and/or regeneration by vacuum desorption to space. Novel concepts to provide potable and hygienic water are needed that eliminate the expendables, are highly reliable, and operate in micro- or partial gravity. This project addresses this need with a directional freeze crystallization system operating in a batch process. Freeze crystallization can remove more than 90 percent of dissolved solids, organic chemicals, particulates, and microorganisms from water. This approach would not require expendables, would have an energy consumption comparable to membrane distillation, and would use proven vapor compression refrigeration technology. This approach also builds upon the company's experience with crystallization for household water purification appliances. Water to be reclaimed would fill a cylinder and be cooled through the cylinder wall by a refrigerant. Crystals of purified ice would form on the wall, thereby concentrating the impurities within an unfrozen core. Typically one-half or more of the water would be crystallized in each batch. The liquid core would then be drained from the vessel, and the purified ice melted using heat rejected from the refrigerant condenser.

Potential Commercial Applications: Applications include water polishing on Space Station Freedom, industrial water treatment, wastewater treatment, and food processing.

***

278 JSC
92-1-12.04-3149 NAS09-18854
Solid Waste, Chemical Oxidation Unit for Closed Environments
Lynntech, Inc.
111 East 27th Street, Suite 204
Bryan, TX 77803
G. Duncan Hitchens (409-822-3149)

The company has developed an innovative oxidation process capable of treating solid organic wastes for recovery of highly valued materials in a controlled, ecological life-support system (CELSS) environment. Regenerative systems for food, air, and water will largely depend upon recovery of reusable resources from solid wastes. This new catalytic reaction process is highly effective for oxidizing a wide range of typical CELSS materials, including inedible biomass and plastic (e.g. Teflon). This process would completely convert waste, operate without expendables, and present several physical and chemical system advantages. During the company's preliminary study, a laboratory bench-scale reactor system was assembled and tested, and organic oxidation tests were carried out in a temperature range of 600 to 700°C at ambient pressure. Test results showed that waste pretreatment was not required, oxidation was extremely rapid, the offgas was essentially free of toxic substances, and the inorganic materials formed during the process were predominantly simple salts. These results have provided a sound technical basis for the design and implementation of the Phase I project. The objectives of Phase I will be to demonstrate the feasibility of the reactor system, to conduct experiments to obtain parametric data for mass balance calculations, and to determine the fate of nitrogen compounds and mineral salts.

Potential Commercial Applications: This technology can be used for hazardous waste treatment and industrial effluent clean-up. The process is attractive for the destruction of chlorinated hydrocarbon pollutants and chlorofluorocarbons (CFCs).

***

279 MSFC
92-1-12.04-3200 NAS08-39834
Resistance Heating of Zeolites and Silica Gels for the Removal of Carbon Dioxide and Water Vapor
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
Harris Gold (617-890-3200)

Because future space travel will involve long periods of time, closed-loop environmental control and life-support-systems must be changed to meet the demands of these missions. A regenerable carbon-dioxide removal system involving four zeolite beds will be developed for the Space Station Freedom. While current designs present power consumption and system weight problems, this project may dramatically reduce the energy required for thermal regeneration and provide for the removal of carbon dioxide without the use of a desiccant bed, thereby reducing the system's power, weight and volume. The system will add small quantities of conducting filler material to the adsorbent beds, which will be fitted with electrodes connected to a power supply. Uniform and efficient heating of the beds is accomplished by resistance heating of the conductive material which serves as a current path. The objectives of Phase I are to demonstrate on a laboratory-scale that zeolites and silica gels can be efficiently regenerated with resistance heating; to develop conceptual designs; and to conduct mission requirements analysis to determine the most suitable design for the Space Station Freedom.

Potential Commercial Applications: This system's commercial applications would include the increased use of adsorbent systems for dehydration (desiccation); purification of nonpolar gases (such as natural gas or hydrogen) containing contaminant polar and unsaturated compounds such as hydrogen sulfide, sulfur dioxide, carbon dioxide, ammonia, carbonyl sulfide and mercaptans; odor removal; and the removal of hydrocarbons from manufactured and coke-oven gas.

***

280 MSFC
92-1-12.04-3291 NAS08-39843
Integrated Oxygen Recovery System
Life Systems, Inc.
24755 Highpoint Road
Cleveland, OH 44122
M.G. Lee (216-464-3291)

An innovative, integrated oxygen recovery system (IORS) applicable to advanced mission air revitalization will be developed. Within a single assembly, the IORS can electrochemically generate metabolic oxygen (O_2) and recover O_2 from the space habitat atmosphere via a carbon dioxide (CO_2) reduction process. To do these functions, the IORS utilizes a novel, solid-metal-cathode (SMC) water electrolysis unit that simultaneously serves as the Sabatier CO_2 reduction reactor. The IORS enables two major life-support systems currently baselined in closed loop air revitalization systems to be combined into one smaller, less complex system. This concept reduces fluidic and electrical interface requirements and eliminates a hydrogen (H_2) interface. Furthermore, since the IORS utilizes an SMC, the system can also generate high pressure O_2 (i.e., >1,000 psia) for recharging extravehicular-activity O_2 bottles. This capability is not available with current baselined or planned technologies. The company will perform a process evaluation on the IORS, which will demonstrate performance and quantifying key system physical characteristics including power, weight, and volume. This evaluation should provide the feasibility results to proceed with Phase II.

Potential Commercial Applications: In addition to potential applications in life support systems of future advanced missions, the IORS process may also be used as part of a military air revitalization system for a defense shelter. Furthermore, due to increasing energy-related concerns, the IORS process may be applied to commercial hydrogenation processes such as CO_2 methanation and coal gasification.

***

281 ARC
92-1-12.04-5628 NAS02-13778
Sterilization of Drinking Water on Human Planetary Missions
Maine Research & Technology Company
Mit Branch, P.O. Box 266
Cambridge, MA 02139-0902
Milan Tekula (617-233-5628)

The primary objective of water treatment is to take water from any available source and to process it so that it both tastes good and is safe for human consumption. Water treatment must, therefore, remove, toxic chemicals and biological pathogens. In space, this process must also minimize consumables; therefore, a waterfiltering device must be efficient, lightweight, and able to sterilize filtered urine, washwater, and condensates. This project will use a contact glow charge to test a new device for the sterilization of water. This effort will analyze the concept and test the approach's feasibility. Specifically, the process will use hydroxyl radicals to make water, thereby requiring no consumables and operating in a partial gravity environment. The devices based on this concept will be especially useful in NASA's future human planetary space exploration missions because these regenerative life support systems do not require expendable materials, are lightweight, operate in partial gravity, and have high reliability.

Potential Commercial Applications: The research in this program will provide NASA with a plentiful supply of good, healthy drinking water for long term space flights. It will also find use at water purification plants on Earth, which will help to reduce the long-term financial burden that can result from bacteriological and chemical contamination of drinking water.

***

282 MSFC
92-1-12.04-7505 NAS08-39815
In Situ Polymerization of a Reverse Osmosis Membrane for a Regenerative ECLSS
King Lee Technologies
6440 Lusk Boulevard, Suite D102
San Diego, CA 92121
David L. Kronmiller (619-457-7505)

As manned-mission profiles change from short duration, small crew to prolonged larger crew missions, the environmental control and life-support system (ECLSS) changes from an open to a closed system. Therefore, water recycling is a major consideration. Currently, the most cost efficient process for H_2O recovery is a reverse-osmosis (RO) filtration system. RO filtration does not require a gas-liquid phase separator in zero gravity and has lower energy consumption than phase change processes. The types of reverse osmosis membranes considered to date have either the hollow-fiber (HF) or dual-layer (DL) membrane. HF membranes suffer from a high fouling rate, low throughput, and lower salt rejection. DL membranes have high-flow throughout but also suffer from a high fouling rate and chemical instability. This project will develop a new semipermeable membrane material that operates at pressures of less than 690 kPa (100 psi), with better flow throughput, and less fouling potential. The RO membrane materials will be produced by laser-initiated in-situ polymerization of pyrrolidone, substituted pyrrolidones, maleimide, and maleic anhydride derivatives. This new semipermeable membrane will allow more efficient energy use on missions requiring closed or partially closed ECLSS.

Potential Commercial Applications: The project is a basic material science, proof-of-concept effort. If successful, it will introduce a new semi-permeable membrane material into the reverse osmosis, high-purity water technology. The material could replace the current RO semi-permeable membranes.

***

283 KSC
92-1-12.05-0300 NAS10-11978
Efficient, Full-Spectrum, Long-Lived, Non-Toxic Lamp for Plant Growth
Fusion Systems Corporation
7600 Standish Place
Rockville, MD 20855
Donald A. MacLennan (301-251-0300)

A mercury-free, low-infrared, efficient lamp has been developed using proprietary, benign lamp-fills optimized for visible light. The project will investigate lamp-fill parameter variations with the goal of optimizing the lamp's spectral output and efficacy (efficiency) for plant growth while maintaining its non-toxic and low infrared properties. The lamp's spectral output will be improved to include substantial blue, red, and far-red components required by many plants. The new lamp is a microwave-powered, bright, long-lived, stable, light source with a continuous, visible spectrum. Other benefits include its small size and spherical shape which provide ease of optical control, and its reduced IR- and UV-radiated outputs which are significantly lower than most discharge lamps. The company will perform energy balances for various benign lamp-fills and lamp parameters. In an iterative process, electrical, thermal, and optical variables, including lamp spectra, will be measured. Potentially successful candidate lamp-fills and parameters will be cataloged using spectral guide-

lines obtained from NASA scientists. A successful Phase I effort should lead to Phase II production of efficient, low-infrared, non-toxic lamps and lamp-system components for NASA's plant growth requirements.

Potential Commercial Applications: Commercial applications for this plant growth lighting innovation are in three areas: experimental plant growth chambers in use at colleges, bio-technology concerns, and government; enclosed, artificially lighted plant growth factories pioneered in this country and now in use primarily in Japan; and supplementary, early season lighting for commercial nurseries and farms.

***

284 ARC
92-1-12.05-2650 NAS02-13770
An Ultrasonic Biocidal System for Hydroponic Plant Nutrient Solutions
Biotronics Technologies, Inc.
W226 N555B East Mound Drive
Waukesha, WI 53186
Kenneth J. Schlager (414-896-2650)

Ultrasonic cavitation has been shown in a number of experimental studies to have a destructive (biocidal) effect on bacteria and other microorganisms. This project calls for an experimental investigation to determine the feasibility of an integrated ultrasonic system to control levels of bacteria and fungi in a closed, environmental life-support system environment. The stable and transient forms of cavitation will be investigated over a range of frequencies from 25 kHz to 1.9 MHz. Both pulsed and continuous wave systems will be evaluated with a variety of transducers and power supply configurations. Two experimental ultrasonic generators will be designed, constructed, and tested to demonstrate the feasibility of the ultrasonic biocidal system concept. These two experimental systems will be evaluated at The Land, EPCOT Center, under the direction of Dr. Andrew Schuerger, senior plant pathologist. Two new developments have greatly increased the probability of success of this project: the concept of ultrasonic treatment in the nutrient solution reservoir that allows time for cavitation action; and the availability of all of the principal components of the experimental system including the ultrasonic transducers that have recently become available.

Potential Commercial Applications: An ultrasonic biocidal system would have tremendous market potential in the water and wastewater treatment industry. Current environmental concerns and new environmental regulations have stimulated great interest in finding alternatives to chlorination for control of pathogenic bacteria.

***

285 KSC
92-1-12.05-7070 NAS10-11980
Selective Ligand Surfaces for Nutrient Solution Monitoring and Control
Geo-Centers, Inc.
7 Wells Avenue
Newton Centre, MA 02159
Mary Beth Tabacco (617-964-7070)

Phase I will demonstrate the feasibility of fabricating ligand surfaces of crown ether macrocycle which exhibit selective binding for metal ions. The project will use state-of-the-art research in self-assembled monolayers and molecular assemblies. The selective ligand surfaces developed under this project can be applied to monitor and control essential ionic nutrients in hydroponic growth media as required for the regenerative production of food. The primary goal in Phase I will be to synthesize the functional ligand surfaces of chromogenic macrocycles and to verify metal complexation. This process will demonstrate that several crown ethers can be successfully chemisorbed on a substrate, that functionality is maintained, and that there are notable differences in the uptake for individual metal ions of interest to NASA.

Potential Commercial Applications: Self-assembling and selective ligand surfaces hold tremendous potential for custom engineering of microsensors, electronics, microscale pumping and switching, and in biotechnology. The specific macrocycle ligand surfaces developed in this program can be used for detection of toxic heavy metals in both natural and process control waters and in commercial hydroponic and aquaculture ventures.

***

286 KSC
92-1-12.05-7070A NAS10-11979
Carbon-Dioxide Monitoring System for CELSS Applications
Geo-Centers, Inc.
7 Wells Avenue
Newton Centre, MA 02159
Mary Beth Tabacco (617-964-7070)

This project will apply chemical optrode technology to the difficult problem of CO_2 detection. The Phase I objective is to design, construct, and evaluate an all-optical probe to detect carbon dioxide from 0 to 3000 ppm with resolution ±2 ppm. This probe will meet NASA's need for monitoring variable CO_2 levels in controlled, ecological life-support systems (CELSS) as required for the regenerative production of food. The sensor is innovative because it will be suitable for monitoring both atmospheric and dissolved CO_2, which may be required in various subsystems of a CELSS, such as resource recovery. In addition, by virtue of its size, weight, electromagnetic interference immunity, compatibility with microprocessor control systems, and minimal manning and expertise requirements, the sensor is well suited for use on flight experiments. The

C12.

development of an integrated, multisensor, CO_2 monitoring system in a subsequent Phase II effort will provide NASA with a reliable, highly portable and analytical instrument that is ready to meet several monitoring and control applications.

Potential Commercial Applications: The CO_2 monitoring system would be useful for NASA, NASA contractor, and domestic and international space-oriented business applications. The system should also find broad application in the agricultural community, particularly for hydroponic and emerging aquaculture applications. The CO_2 sensors could be used in monitoring fermentors and as a patient monitor in surgical procedures.

***

287 ARC
92-1-12.05-7071 NAS02-13769
Supercritical Water Oxidation of Inedible Biomass
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. The process can be useful for the regenerative production of food in space because it effects a rapid and complete conversion of waste biomass to well-defined inorganic materials that are then made available for new crop growth. Phase I of this project will design a SCWO unit specifically intended to treat inedible biomass. The unit would be constructed under Phase II.

Potential Commercial Applications: This project will broaden the existing database of information used to design SCWO systems for use on Earth to destroy hazardous wastes.

***

288 KSC
92-1-12.05-9450 NAS10-11977
Solid-State Microionic Oxygen Sensor for Closed, Environmental Life-Support Systems
EIC Laboratories, Inc.
111 Downey Street
Norwood, MA 02062
Dennis N. Crouse (617-769-9450)

Monitoring the content and local variability of free oxygen is fundamentally important in regenerative and controlled biomass production environments. These atmospheres, which NASA anticipates for long-duration space missions and planetary base habitats, encompass a relatively narrow range of conditions (pressure, temperature, and gas composition), where O_2 levels must be rather precisely controlled. The goal of this project is to develop an all solid-state, thin-film, self-powered, galvanic, O_2 sensor that is operable in weightless environments under ambient conditions. The sensor, which would have negligible weight and power consumption, would be fueled by a regenerable storage electrode that should operate for more than 10 years. The goal of Phase I is to fabricate such a sensor and to demonstrate its operation under earth-ambient conditions in 1 to 100% gaseous oxygen concentrations. In addition, the project will assess the sensor's operation in a typical greenhouse environment. Phase II's work on the device will improve its long-term operation and calibration under typical plant growth conditions, integrate it with a thin-film or optical CO_2 sensor, and tailor it for specific NASA missions.

Potential Commercial Applications: The amperometric O_2 monitor would represent an improvement over existing galvanic, ambient temperature O_2 analyzers and could serve in process control and safe entry applications.

***

289 JPL
92-1-12.06-1010 NAS07-1233
Fiber-Optic Immunoassay Sensor for Monitoring Life-Support Systems
TACAN Corporation
2330 Faraday Avenue
Carlsbad, CA 92008
Ron Grayson (619-438-1010)

A need exists in non-terrestrial environments to be able to rapidly and accurately identify pathogenic microbial and chemical contaminants in regenerated air and water streams. Present chemical- or bio-sensors are impractical because they have parameter deficiencies in size, weight, complexity, power requirements, specificity, response times, and accuracy. Small, in situ, continuously operating, highly selective, and reliable, fiber-optic-waveguide, immunoassay-chemical sensors and immunoassay-bio-sensors (FOWG-ICs and -IBs) can provide accurate, rapid detection with multiplexing capabilities. This project will demonstrate a laboratory version of a small FOWG-IB incorporating two major innovations. The first is a side-coated, multilayer probe architecture containing monoclonal antibodies, which results in high specificity and much higher sensitivity than other designs. The second innovation uses micro-optic blocks to reduce the size of the sensor optics. Both innovations are extendable to many types of fiber-optic, chemical- and bio-sensors. In addition to in-situ monitoring of regenerated air and water streams, many other applications can be found for these sensors, including the assurance of safe public water supplies and the determination of wastewater treatment effectiveness. Other versions of this sensor can be used to monitor propellants and other toxic materials.

Potential Commercial Applications: This work will yield a small, highly sensitive bio-sensor which can monitor water supplies for microbes. Other uses include monitoring coliform levels in wastewater and swimming areas

and monitoring public places for airborne diseases. Versions can be used in pollution monitoring, tank leak detection, biomedical applications, food testing, and hazardous materials monitoring.

***

290 JSC
92-1-12.06-2009 NAS09-18859
Reagentless Oxidation Reactor for Total Organic Carbon Analyzer
Sievers Instruments, Inc.
1930 Central Avenue, Suite C
Boulder, CO 80301
Richard Godec (303-444-2009)

The project will develop a new technology for the oxidation of organic compounds that will then form carbon dioxide without the use of chemical reagents but as part of a system for the measurement of total organic carbon (TOC) in water. Using a combination of electrolytic and photolytic oxidation should permit complete and rapid oxidation for a wide range of organic compounds to form CO_2. Preliminary experiments indicate that complete oxidation of methanol can be obtained at concentrations as high as 43 ppm of carbon, although additional research and development are required to provide long-term, high-oxidation efficiency. The oxidation reactor will be incorporated into a TOC analyzer developed by Sievers Instruments for the Crew Health Care System program and should find application in the environmental control, life-support system for Space Station Freedom and future manned missions. Successful completion of the research will lead to the development of an accurate TOC analyzer compatible with operation in a microgravity environment, with minimal use of chemical reagents, low maintenance, and almost no astronaut interaction required.

Potential Commercial Applications: Commercial applications include water quality measurement and water purification. Typical commercial users of this technology include electronics and pharmaceutical manufacturing, biotechnology, hazardous waste management, and electrical power industries.

***

291 JSC
92-1-12.07-2567 NAS09-18835
Eliminating Glare in Space Crew Flight and Habitat Environments
Advanced Environmental Research Group
Route 2, Box 2948
Davis, CA 95616
Richard Ian-Frese (916-757-2567)

The project will develop a light-guide device with controlled scattering capabilities. The device is intended to eliminate glare or high-contrast lighting conditions. Its primary use is with high-efficiency fluorescent and halogen light sources. Because habitats create a total environment within which the space crew will live and work, lighting conditions can have a significant impact on the mental and psychological conditions of the inhabitants. In space, high-quality illumination will positively affect human-factor considerations. Project objectives are to make and characterize a prototype device that will best guide the source light to a mathematically determined density profile of scatterers suspended within a thin, optically transparent material. The device should permit long use while making its light intensity more even. NASA crew comfort and associated performance improvements will result from an enhanced lighting environment. The result efficient distribution of light will also impact available energy reserves by displacing in-flight and long, diurnal-cycle power requirements which otherwise, ultimately, compromise mission objectives.

Potential Commercial Applications: In the U.S., about 25 percent of total electrical output is used for lighting. By using efficient lighting, Americans could save about $20 billion a year and prevent millions of tons of additional air pollution. The high-quality, high-efficiency lighting innovation has strong potential in the existing international commercial marketplace.

***

292 JSC
92-1-12.07-5090A NAS09-18832
Cognitive and Performance Readiness of Space Crews
Essex Corporation
1040 Woodcock Road, Suite 227
Orlando, FL 32803
Robert S. Kennedy (407-894-5090)

Substantial physiological changes occur with protracted exposure to microgravity. Upon return to earth, space crews must go through a period of re-adaptation. While it is not known whether any of the biomedical changes seen upon return are present during the course of space flight, it is reasonable to assume that they are. Documenting potential performance decrements during a mission is problematic because the performance requirements of space crews are so complex and varied that no single metric exists for indexing performance in space. The approach in this project is to use a standardized, well-documented performance battery that will be augmented for the particular potential problems that are likely to coincide with the known physiological changes produced by microgravity. When administered for less than 10 minutes, the tests have excellent psychometric properties (stability, reliability) and elsewhere have been shown to be sensitive to sleep loss, hypoxia, halon, and alcohol. In Phase I, the project will test this battery and other tasks during lengthy flights on a commercial airliner. In Phase II, the tests in the battery will be housed in a fully automatic, in-flight performance measurement system, and an aircrew self-testing program will be implemented. To shorten the

battery, multiple regression analyses using agents which occasion decrement will be employed.

Potential Commercial Applications: An automated, in-flight, aircrew performance measurement system could be used in fitness-for-duty settings where task demands include control of dynamic vehicles such as aircraft, trucks, cars, and ships. The test could also be employed to assess the effects of those environments where fatigue, environmental agents (motion, vibration) and work conditions (confinement, exercise) alter human performance.

***

293 ARC
92-1-12.08-3088 NAS02-13787
Three-Dimensional Displays with A 360° View for Space Crew
Physical Optics Corporation
20600 Gramercy Place, Suite 103
Torrance, CA 90501
Tin Aye (310-320-3088)

The firm will develop a class of innovative, real-time, autostereoscopic, three-dimensional displays capable of providing a 360° view of an observer's immediate surroundings as would be perceived from a distant, back-shifted imaginary platform. This approach is especially beneficial for space crews performing dynamic maneuvering tasks (such as docking or robot control), because they will be able to view their spatial location with respect to their immediate surroundings and, therefore, will maintain peak situational awareness. The firm will implement this concept by using a multiplexed-volume, holographic display panel as well as simple projection systems that have conventional optics. Due to the specificity of holographic optical elements, the display will provide bright, full-color, high-resolution, three-dimensional images with many perspective views and will overcome the drawbacks of current state-of-the-art, three-dimensional display devices. The device is compatible with current liquid-crystal-projection TVs or AMLCD technologies and, because of its possible reflective mode, it can also be integrated on top of a conventional display panel. Phase I research will involve a thorough study of three-dimensional display concepts that have a real-time, 360° view for space crew onboard systems and for robot management.

Potential Commercial Applications: Because it uses real-time, the firm's three-dimensional holographic display system will find a wide range of applications in military and commercial space products. Near future applications include surveillance photogrammetry training and simulation, three-dimensional video and cinema, molecular modeling, telerobotics, industrial inspection, and CAD applications in manufacturing and medical imaging.

***

294 MSFC
92-1-12.09-0769 NAS08-39816
Virtual Reality Ultrasonic Positioning System
Tomorrowtools
P.O. Box 6083
Huntsville, AL 35824
Ricky J. Roberson (205-721-0769)

A two-part, anthropometric, position-monitoring system will be developed. First, small electronic perimeter units will flood a volume of space with precisely controlled ultrasonic and infrared pulses. Second, these invisible, inaudible pulses within the volume will be detected by sensors mounted on a user-worn bodysuit. Position and pointing of the user's head, torso, calves, thighs, feet, upper arms, forearms, and hands will be measured in real-time with millimeter accuracy at 30 samples per second. This process improves upon existing technology because infrared links replace unwieldy cables, ultra-sound replaces inadequate magnetic and tension sensors, and more accurate positioning data will be obtained at lower cost. The company will write BodyElectric software module to interface this device with the existing NASA Marshall Space Flight Center, Human Factors Laboratory's virtual reality system. The device will be called VIRUPS (virtual reality ultrasonic positioning system).

Potential Commercial Applications: VIRUPS offers a new way to input position data into virtual reality simulations, thereby significantly improving the existing commercial methods. The VIRUPS hardware promises to be cheaper, more accurate, and more convenient to use. These factors, combined with the explosive growth foreseen in the virtual reality market, should make VIRUPS a commercial success.

***

295 MSFC
92-1-12.09-1142 NAS08-39842
HeadMouse: A Head Direction, User-Computer Interface
Eyetech Corporation
416 S. Linn Street, Suite 9
Iowa City, IA 52240
Shaugun Pan (319-339-1142)

HeadMouse is an inexpensive, microprocessor-controlled, infrared-light-based system that indicates head position in real-time. This system enables an operator to control the cursor movement on a computer or a display by using only head movements without the need for head constraints or head-mounted equipment (glasses, helmet, etc.). By changing head direction, the user can position the cursor in the same manner as a conventional mouse. Therefore, any software that incorporates a mouse can be used with this system. The HeadMouse can establish the user's habitual motion dimensions in partial-gravity environments and can incorporate the user's postural input in real-time,

fully interactive, virtual reality systems, which will free the user's hands to accomplish other manual tasks.

Potential Commercial Applications: Such a head direction, man-machine interface will be competitive for the general personal-computer "mouse" market and have significant advantages in laptop, disabled, oriental character, entertainment, and military markets. It could also be easily adapted to operate as a three-dimensional head-mouse.

***

296 MSFC
92-1-12.09-4561 NAS08-39835
Computer-Operated, Nictating Telemetry, Remote-Operation, Lightweight System
Energy Optics, Inc.
224 North Campo
Las Cruces, NM 88001
Edward N. Laughlin (505-523-4561)

The project will develop and demonstrate an infrared, free-space control system which is operated by purposeful eye-blink commands that permit hands-free operation. The computer-operated, nictating telemetry, remote-operation and lightweight (CONTROL) system meets the need for a man-machine interface that will enable the human operator to control the surrounding systems while simultaneously performing hands-on tasks. Using pulsed infrared as the communication medium, the CONTROL system will, via purposeful eye blink, transmit to the remote receiver unit, which will have output control capabilities for surrounding systems. Advancements in the CONTROL system could have far reaching benefits, leading to an interface tool for personal computers mounted in headgear. During an extravehicular equipment repair or seizure, an astronaut could, with eye blink control, flip through a technical manual or view mechanical blue prints on a flip-down, heads-up display in the headgear visor. During preflight checks, an operator could process all of the nonflight equipment for removal verification while using the infrared communications link.

Potential Commercial Applications: The CONTROL system could be expanded to television and radio receivers, tape recorders, and other devices that require hands-free operation–lights, antenna panels, and manipulators. This remote technology could also be developed into a consciousness monitor for vehicle operators. Other applications include control needs for an assembly line operator, safety stops, and line-of-sight voice communications.

***

297 JSC
92-1-12.10-5801 NAS09-18871
Low-Cost Inventory Management and Crew-Tracking System
Direct Current-Light
3940 Marine Avenue, Unit G
Lawndale, CA 90260
Stephen Dale Smith (310-973-5801)

The space station must have accurate inventory management of consumables and crew equipment. The individual crew members must also be constantly monitored. These tasks should be accomplished with a system using the least amount of power, size, and cost, while at the same time demonstrating ease of use, reliability, and acceptable interface with other space station systems. Radio frequency identification (RFID) systems can locate a specific tag within an RF field. However these systems are based on sophisticated data transmission techniques along with complicated and expensive tag circuitry. One of these systems was previously studied and determined to be beneficial to the space station effort. This project will investigate a new, empirically conceived process that will simplify the tag-interrogator system by a magnitude of five. In addition, the system will be faster than previous RFID systems, have lower power consumption, potentially smaller tag sites, and a greatly reduced cost. Accuracy and reliability will be determined while measuring actual power consumption and EMI interference. As part of this project, prototype hardware will be delivered to NASA for future testing and evaluation.

Potential Commercial Applications: A low-cost RFID system would suggest commercial applications such as a tracking system for lost or missing people–babies from hospitals and children lost in malls or amusement parks. Also, hikers, skiers, and hunters will enjoy a greater degree of safety while utilizing this tracking system. This device could also be integrated into a complete management system to control various home or business functions, i.e., lights, locks, doors, HVAC, alarms, and machinery.

***

298 JSC
92-1-12.10-8100 NAS09-18834
Active Microwave Elements for Space Station Food Preparation Systems
Aptek, Inc.
1257 Lake Plaza Drive
Colorado Springs, CO 80906
Daniel C. Osborn (719-576-8100)

To enhance comfort, performance, and productivity of crew members, the concept of reusable, active microwave elements (AME) will be developed for daily meal preparation aboard the Space Station Freedom (SSF) and future manned missions. The innovative AME, placed adjacent to or surrounding a food package in the Station's oven, will redirect microwave energy,

retain heat, and monitor food package temperature and water content. The anticipated results are a significantly improved control of thawing, heating, and holding procedures for individual food packages, problem-free preparation of hot meals for the entire crew, and savings in heating time and Station power.

Potential Commercial Applications: The AME concepts should have application in commercial airline food preparation systems, the higher quality fast food industry, future NASA and SDIO missions, the DOD food services, and rail and busline food preparation systems. In addition, specific microwave measurement techniques may be used to characterize the electrical properties of foods and to control quality in food package assembly.

***

299 JSC
92-1-12.10-8152 NAS09-18868
Manual Apparel Cleaning System for Extended-Duration-Orbiter Shuttle Missions
Johnson Engineering Corporation
3055 Center Green Drive
Boulder, CO 80301-5406
John A. Ciciora (303-449-8152)

This project's objective is to develop and evaluate an austere manual apparel cleaning system (MACS) for use in laundering selected items of clothing on extended duration orbiter (EDO) shuttle missions. Plans to extend shuttle missions to 30, 60, and perhaps 90 days would strain the onboard stowage capability for clothing and other consumables. The laundry system currently being considered for Space Station Freedom (SSF) would be costly and difficult to integrate into the existing shuttle crew compartment. This project addresses these problems with a simple, compact, lightweight system that does not consume orbiter power or involve complex interfaces. Phase I will demonstrate the feasibility of a safe, comfortable, productive, and effective MACS through thorough requirements analysis and testing, and design.

Potential Commercial Applications: Potential commercial users of the MACS include travelers in motels, motor homes, trains, or boats, as well as people in isolated settings such as campgrounds, scientific outposts, and military expeditions and installations. Other NASA users include manned missions to Mars.

***

300 JSC
92-1-12.11-0540 NAS09-18852
A Magnetostrictive Water Pump for Use in Extra-Vehicular Activity
Satcon Technology Corporation
12 Emily Street
Cambridge, MA 02139-4507
Michael J. Gerver (617-661-0540)

The firm will test a new concept for a water pump using a magnetostrictive actuator which has a stroke of 100 μm at 490 newtons. The actuator will periodically push against the diaphragm of a water reservoir about 70 cm^2 in area, connected via input and output valves to a water line, pumping against a pressure of 5 psi. A frequency of 100 Hz adequate to achieve the desired flow rate of 100 kg/hr, and the mechanical power will be comparable to or greater than the resistive loss in the actuator coil, the inertia loss, and the valve loss. A frequency of 100 Hz noise could be greatly reduced by using two reservoirs that are 180° out of phase. This design has essentially no moving parts except for the valves, so it should be more reliable than conventional pumps. Magnetostrictives are superior to piezoelectrics for this purpose because they use much lower voltage, do not age, and have somewhat greater maximum stroke. The objectives of Phase I are to demonstrate the principle with an inexpensive test and to optimize the design for a fully packaged prototype to be built in Phase II.

Potential Commercial Applications: Potential uses are in cryogenic pumps or any pump where reliability or durability is critical, and in the replacement of hydraulic actuators (e.g. on aircraft) with hybrid electric-hydraulic actuators.

***

301 ARC
92-1-12.11-1980 NAS02-13776
Fullerene Hydrides Cooling System for Extra-Vehicular Activities
Materials & Electrochemical Research
7690 South Kolb Road
Tucson, AZ 85706
R.O. Loutfy (602-574-1980)

A new form of hydride - fullerene-hydride - will be developed as an innovative approach to meet new extensive requirements for extravehicular activities (EVAs) of future, complex manned space missions. Fullerene-hydrides, $C_{60}H_x$, have a significantly improved volumetric and weight density for hydrogen storage than the best metal-hydrides. Preliminary thermal calculations also indicate that this novel material could offer additional thermal advantages. Thermal and physical properties of the $C_{60}H_x$ will be determined, and the use of fullerene-hydrides in heat pump concepts mode will be evaluated experimentally. Preliminary engineering system design will be performed to establish the mission suitability of the concept.

Potential Commercial Applications: Lightweight, high volumetric density, thermally efficient hydride compounds, such as fullerene-hydrides, are anticipated to have a wide commercial application beyond the EVA applications, such as Ni-hydride batteries, hydrogen purification refrigeration, and energy storage.

***

302 JSC
92-1-12.11-2900 NAS09-18850
Piezoelectric Water Pump for Use in Extra-Vehicular Activities
Stress Engineering Services, Inc.
13800 Westfair East Drive
Houston, TX 77041-1101
Christopher Matice (713-955-2900)

The objective of the Phase I effort is to define requirements, perform trade studies, and to develop a working plan for fabricating and testing a prototype, low-power piezoelectric pump for the distribution of coolant fluid in portable life-support systems. Two general design approaches merit Phase I analysis. The fundamental principle of the first concept is a changing-volume "drive block" within a fixed-volume housing. The piezoelectric pump drive block is composed of a number of biconvex unit cells arranged to obtain the required flow and pressure. When the drive block is at a maximum volume, fluid is forced out through a check valve. Conversely, when the drive block collapses to a minimum displacement, fluid is drawn into the pump. The second type of device takes advantage of the unstable buckling of a piezoelectric plate fixed in a rigid frame. As the plate buckles from one metastable position to the next, fluid is drawn into and out of the pump body. Analysis of the basic system will be used to develop the most promising concepts to a preliminary design stage.

Potential Commercial Applications: Small pumps are commonly used in a wide variety of applications. In addition to active thermal cooling applications, piezoelectric pumps can act as electro-mechanical actuators. As an actuator, this pump may provide solutions to control system problems in robotics, bioengineering, advanced remote control, and telepresence technologies. There is also great demand for output devices that are more energy efficient, rugged, economical, and easier to control than conventional actuators.

***

303 JSC
92-1-12.11-8933 NAS09-18858
Miniature High-Resolution Display
Displaytech, Inc.
2200 Central Avenue
Boulder, CO 80301
Mark Handschy (303-449-8933)

The miniaturization of high-resolution information displays presents a problem that will be difficult to solve by extending existing display technologies. Phase I will investigate a solution that utilizes a novel combination of existing technologies, namely ferroelectric, liquid-crystal light modulators and active-matrix backplanes made of conventional, crystal-silicon integrated circuits. This project will demonstrate that the displays overcome fundamental resolution limitations of more orthodox technologies. The Phase I effort will concentrate on designing and demonstrating a small array of the highest resolution pixels feasible in 1.2 μm design-rule CMOS processing. Phase I will also identify the development paths to even higher resolutions for work conducted during Phase II. In particular, Phase II will develop display elements with more than one million pixels which are suitable for full-color, head-mounted displays. These elements can be used as stereoscopic-virtual-reality or telepresence displays and as computer and communications displays in space suit helmets.

Potential Commercial Applications: In addition to commercial virtual reality applications similar to NASA's, the technology can be extended to high-definition projection displays and ultra-resolution flat panels.

***

304 JSC
92-1-12.12-1112 NAS09-18833
Charge-Coupled-Device and CMOS High-Efficiency, Low-Voltage Regulator
Q-Dot, Inc.
1069 Elkton Drive
Colorado Springs, CO 80907-3579
Donald L. Herman, Jr. (719-590-1112)

The firm will develop an innovative "no-drop" regulator (NDR) for micropower systems. Based upon charge-couple devices (CCDs), the NDR provides both voltage multiplication unattainable from linear regulators and higher efficiency with less noise than switch-mode regulators. While the NDR is designed for battery or solar-cell systems, it also has zero-volt, input-to-output differential for no-drop regulation. A 3 V, NDR-based system requires only one ≈1.5 V battery (or solar cell), which results in less size and weight while providing more efficient operation. On the other hand, a linear regulator's inherent diode drop requires three batteries and a switch-mode regulator includes an isolation diode, which therefore reduces its efficiency and limits its maximum input voltage to a diode drop above the desired output voltage. The NDR provides isolation without a diode, allowing operation with higher voltages. Multiphase CCDs produce lower noise and ripple than conventional switch-mode regulators. Thus, more efficient, lower-noise operation over a wider voltage range than competing regulators is possible. In particular, the NDR can be applied to electronic (CCD) cameras that use CMOS-support circuitry because the NDR can be readily integrated for a single-chip solution.

Potential Commercial Applications: The regulators can be used in hand-held telecommunication, global positioning, or imaging systems; notebook and laptop computers; cellular phones and mobile radios; remote sensors and data collection systems; pagers, beepers, and other remote signalling devices; and any low-powered, battery or solar-cell operated system.

***

305 JSC
92-1-12.12-6465 NAS09-18930
Multi-Layered Optical Data Storage
Strickler Optical Technology, Inc.
109 Harvard Place
Ithaca, NY 14850
James H. Strickler (607-277-6465)

Multi-layered optical data storage will potentially provide "read-only", "write-once", and rewritable disk media with data densities up to 100 times that of conventional single layered media. Data may be written to a selected plane without corrupting data in neighboring planes by two-photon excitation of the recording photochemistry. Quadratic dependence of the two-photon absorption rate on incident intensity confines writing to the focal plane. Data may be read from a selected plane without crosstalk from neighboring planes by wavefront shearing interferometry. In the firm's early experiments, data densities exceeding 10^{12} bits per cm^3 were achieved in 30-layer, "write-once-read-many", photopolymeric refracting samples. Commercial development of multi-layered technology requires improved reflective media and focus and tracking control systems that are adapted to the multi-layered format. During Phase I, the firm will calculate expected performance for a multi-layered "read only" medium and disk drive which will be made into prototypes in Phase II. The project will make calculations based on modulation transfer functions, laser performance, and material parameters. The firm will also determine optimum values for key design parameters, including layer spacing, track pitch, and media contrast. Finally, a multi-layered, "read-only" medium sample will be fabricated and tested.

Potential Commercial Applications: Optical read-only, write once, and rewritable data storage devices are already preferred for data dissemination, archival, and storage in many areas, including imaging sciences, because of their high capacity, durability, and rapid access. A one or two order of magnitude increase in media capacity will have many commercial applications.

***

306 ARC
92-1-12.13-9591 NAS02-13809
Biotechnology Instrumentation for the Support of Embryogenesis
Space Hardware Optimization Technology, Inc.
P.O. Box 351
Floyd Knobs, IN 47119
John C. Vellinger (812-923-9591)

Two goals of NASA's Space Life Sciences program –basic human adaptation to space and human exploration and habitation of space–require that biological research models be established along with the support biotechnology instrumentation. This project will develop an experimental tool that will provide maximum control of both experimental and flight variables, thereby giving developmental biologists extraordinary research opportunities. While it helps to monitor developing vertebrate organisms, this instrumentation also provides new ways to collect specimens and to detect viability. Further, this apparatus gives life scientists the controls for exact duplication of experimental variables. Phase I will investigate the feasibility of an advanced, biotechnological spaceflight instrument that will support embryogenesis in microgravity.

Potential Commercial Applications: This new instrument will foster the commercialization of the biotechnological industry. Using this biotechnological instrumentation, researchers may also discover important data which could help develop medical and biological systems and equipment to overcome human physiological problems associated with microgravity, such as the loss of bone mass, muscle atrophy, the loss of fluids and electrolytes, cardiovascular changes, and vestibular disturbances.

***

13: Quality Assurance, Safety, and Check-Out for Ground and Space Organizations

307 KSC
92-1-13.01-0054 NAS10-11981
Comprehensive Predictor of Lightning Strikes by Place and Time
Ktaadn, Inc.
1340 Centre Street, Suite 202
Newton, MA 02159
Donald S. Frankel (617-527-0054)

This project will evaluate an innovative neural-network, natural lightning predictor that uses new types of meteorological parameters (e.g. temperature, humidity) as inputs and training data histories from several epochs earlier than the 'current' epoch. The predictor will indicate where future lightning strikes will occur in time (T=0, 15 min., 30 min., 1 hr., 2 hrs.) over 16 different (5 x 5 nmi.) 'tiles' covering the Kennedy Space Center. The predictor's feasibility will be demonstrated with its increased probability of predicting a lightning strike above the 0.50 value (with a probability of false alarm < 0.001) over the current state-of-the-art system described by Frankel and Draper (1990). Based on Phase I results, will be made for a comprehensive (natural and initiated) lightning predictor will be recommended for the Phase II pre-commercialization prototype.

Potential Commercial Applications: A maker of tactical weather stations has indicated strong interest in the predictor's commercial possibilities, and the utility industry has also expressed interest. With the expertise gained in this project, a prediction capability for agricul-

tural crops, rainfall, forest fires, and protection of commercial airports could be developed.

***

308 KSC
92-1-13.01-8430 NAS10-11976
Improved Lightning Forecast for Kennedy Space Center
Command Control, Inc.
8800 Roswell Road, Suite 130
Atlanta, GA 30350
Jerrold S. Foster (404-992-8430)

A cloud-to-ground lightning forecast model will be constructed from historical meteorological data using an innovative technique known as goal oriented pattern detection (GOPAD). The model will generate 0 to 12 hour probability of lightning forecasts for Kennedy Space Center, with expected forecast accuracies exceeding those of human experts and current forecast models. GOPAD makes predictive indices from the historical databases, which can then be used to provide analogies for forecasts, possibly detecting patterns not discernible to human weather experts. The result is a forecast model that can be used with real-time input data.

Potential Commercial Applications: Accurate weather forecast models are important to public utilities, transportation companies, government agencies, and agricultural companies. GOPAD is also capable of forecasting or diagnosing in domains other than weather.

***

309 KSC
92-1-13.02-1355 NAS10-11974
Sensor System to Monitor Cloud-to-Stratosphere Electrical Discharges
Aster, Inc.
P.O. Box 466
Ft. Collins, CO 80522
Walter A. Lyons (303-221-1355)

The cloud-to-stratosphere (CS) electrical discharge extends from the top of convective storms and propagates vertically several tens of kilometers. Once thought rare, recent evidence suggests the CS may be much more common and thus a potential hazard to aerospace operations in the region 10 to 50 km above the earth. This is of importance to stratospheric photochemistry, magnetospheric and ionospheric physics, and for improving our understanding of cloud electrification. Phase I will extend and synthesize data on the CS event. Additional atmospheric data from known CS events will be used in a detailed statistical analysis of CS characteristics. Extant theories on the cause and nature of the CS event will be reviewed. Next, the feasibility of designing, building, and operating a system capable of monitoring the phenomenology and frequency of CS events will be assessed. Field studies will be designed for Phase II to include low-light television monitoring of intense distant storm tops, correlated with multispectral RF signatures (8 Hz and >10 kHz) and Schumann Q-bursts. Isolating a characteristic signature and deploying a relatively low-cost, operational monitoring system is believed feasible.

Potential Commercial Applications: With the advent of travel by SST aircraft and/or spaceplanes, the need may arise to monitor the CS phenomenon. Commercial applications may include providing the system components or offering a service to aerospace operations analogous to the current commercial lightning groundstroke monitoring networks.

***

310 KSC
92-1-13.02-3633 NAS10-11975
In Situ Measurements of Electric Charge Using the Perseus Unmanned Aircraft
Aurora Flight Sciences Corporation
10601 Observation Road, Manassas Municipal
Manassas, VA 22111
John S. Langford (703-369-3633)

Electric charge resident in clouds, along or near the path of a space vehicle, presents the hazard of triggered lightning. Ground-based electric field mills remotely sense electric charge but alone cannot provide the structure of the electric field aloft. While aircraft-based electric field mills have been used on an experimental basis, they are probably too expensive for operational use. The recently developed NASA Perseus unmanned science research aircraft, however, offers a potential breakthrough in electric field measurements. One Perseus aircraft could carry multiple field mills along with drop-windsondes and perform in situ measurements of water vapor, cloud properties, and radiation at altitudes from the surface up to 30 km for durations of 2 to 3 days at altitudes up to 20 km, and for costs an order of magnitude below those of larger manned aircraft. The data could be telemetered to the ground and integrated into the existing NASA Kennedy Space Center electric charge measuring networking. Phase I will conduct a feasibility study of this concept. Phase II will use the Perseus proof-of-concept aircraft as a testbed for field experiments.

Potential Commercial Applications: If this work is successful, it could lead to routine airborne monitoring of electric fields and other meteorological data for all future shuttle launches.

***

311 KSC
92-1-13.03-7565 NAS10-11983
Compact Laser Microprobe Mass Spectrometer
Moltech Corporation
Engineering Building - SUNY
Stony Brook, NY 11794-2280
Vitaliy E. Shoub (516-632-7565)

A compact, desktop-sized instrument will be developed for real-time trace microprobe analysis of a large variety of industrial and environmental samples. The instrument is based on ultrafast ablation and ionization of a microarea of the sample surface using a tightly focussed nanosecond-duration laser pulse. The ions formed as a result of the interaction of the laser pulse with the solid surface are then analyzed according to their mass/charge ratio using a miniature time-of-flight mass spectrometer. The spot to be analyzed can be observed and positioned for analysis using the laser microscope and X-Y-Z sample positioning and focusing manipulator. This project will define the fundamental and instrumental limitations of the technique and device, prove the concept, and find ways to significantly improve the performance. The new instrument will greatly enhance real-time in-situ analysis of advanced materials, in field or laboratory conditions, down to the ppm level.

Potential Commercial Applications: A desktop, real-time, transportable, microprobe trace analyzer will be able to detect traces of elements and molecules on the surface of a wide variety of industrial and environmental objects as well as in liquid samples. Such an instrument will be widely used in environmental, materials research, and nuclear energy applications.

***

312 KSC
92-1-13.04-4770 NAS10-11988
Diode-Laser Hydrazine Monitor
Spectral Sciences, Inc.
99 South Bedford Street, #7
Burlington, MA 01803-5169
Mitchell Zakin (617-273-4770)

Hydrazine concentrations as low as 10 ppb represent a significant health hazard to people who work where these fuels are used. This project's goal is to develop a diode-laser-based sensor to selectively and sensitively quantify hydrazines in the workplace. The approach combines the technology of reliable gallium-arsenide-based lasers developed for the communications industry with an innovative absorption line-locking and laser-wavelength modulation technique. Line-locking insures rejection of potential interferents, while wavelength modulation allows for much greater sensitivity than can be obtained with conventional absorption methods. In Phase I, a laboratory breadboard will be constructed and used to perform a proof-of-concept demonstration of this approach. The results will be used to complete a preliminary design of a brassboard hydrazine monitor that will be constructed and tested in Phase II. The anticipated result is a sensitive, species-selective, real-time sensor for long-term, unattended monitoring of hydrazines in the 10 to 1000 ppb concentration range. This device can be used at NASA for monitoring hydrazines to ensure worker safety. In addition, it may find use in vehicle health-monitoring programs.

Potential Commercial Applications: The monitor can be used for monitoring hydrazines in the agricultural, plastics, pharmaceutical, and chemical industries. In addition, the diode-laser technology can be applied to a broad range of molecular species and thus further commercial applications in environmental and workplace monitoring are possible.

***

313 KSC
92-1-13.04-7831 NAS10-11985
Fiber-Optic-Based Hydrogen Monitor
Research International, Inc.
18706 142nd Avenue, NE
Woodinville, WA 98072
Elric W. Saaski (206-486-7831)

The development of a portable hydrogen monitoring system is the goal of this project. The approach will be based on interferometric optical principles. The hydrogen detecting element is a thin, sub-micron, multilayer film that changes spectral properties in direct response to changes in hydrogen concentration. The film assembly is deposited on a transparent substrate that can be remotely interrogated over large distances via fiber-optic cable, thereby ensuring safe measurements in explosive atmospheres. Small cross-section probes and sensor tips can be built for pin-point leak detection. This project will develop an all solid-state electronics package that interrogates the sensor with multiple wavelengths derived from long-lived LEDs while providing output data via an LCD readout and digital data link. The optoelectronics is designed so that the base unit can be used as a hand-held survey instrument or a remote readout. Phase I will focus on developing and testing prototype sensors to specifications typical of those needed for detecting hydrogen leaks during prelaunch hydrogen loading of space vehicles.

Potential Commercial Applications: Hydrogen is an offgassing product of electrical equipment that is suffering a dielectric breakdown. The device's most important application would be to monitor large power transformers for unusual levels of offgassing that could indicate an imminent failure and/or explosion. Hydrogen is also used in processes such as ammonia manufacture and hydrogenation.

***

314 JSC
92-1-13.06-1910 NAS09-18838
Selective Sensor for Hydrazine Detection
Inrad, Inc.
181 Legrand Avenue
Northvale, NJ 07647
Zhenyu Zhang (201-767-1910)

Many problems can arise from the use of hydrazine and its derivatives as fuels in rockets and missile systems. To support operations, space flight and ground equipment require state-of-the-art detection and monitoring devices for these propellants. The project's objective will be to develop a moderate-cost, highly sensitive detection system that will operate for long periods of time with little maintenance. Currently, the two techniques used for monitoring hydrazines are electrochemical cells and sensitized papers. However, these techniques are costly and require frequent servicing. This project will use a new technique to prepare a hydrazine-selective polymer film and to use surface acoustic waves (SAWs) to detect an accumulation of hydrazine and its derivatives on this chemically sensitive surface film. These selective sensors can provide highly sensitive, on-line continuous detection of the hydrazines. Therefore, these sensors will greatly simplify testing for hydrazine at NASA facilities.

Potential Commercial Applications: The SAW sensor is designed to detect and quantify hydrazine in space flight and spacecraft assembly for NASA. In addition, it will also be applicable to monitoring hydrazine for missile and other weapons systems and for environmental monitoring of hydrazine. The basic approach can be expanded to other toxic propellants.

***

315 KSC
92-1-13.08-5058 NAS10-11973
Flexible Insulation System Using Ultra-Low Density Aerogels
Aspen Systems, Inc.
184 Cedar Hill Street
Marlborough, MA 01752
Jaesoek Ryu (508-481-5058)

The project will investigate an innovative insulation system that employs ultra-low-density aerogel powder in a flexible, easy-to-use configuration. The design uses the low solid conductivity and reduced gas conduction of aerogel powders and a flexible radiation inhibiting layer to minimize each mode of heat transfer and maximize applicability. The system could be used in either evacuated or non-evacuated environments and as internal or external insulation. The objective of Phase I is to demonstrate the feasibility of the design concept by producing the ultra-low density aerogel in the configuration and by measuring the apparent thermal conductivity of key insulation element prototypes. The material stability issues, including out-gassing and sensitivity to moisture, will also be investigated. Phase II will develop a detailed insulation system design through thermal analysis, optimization of material properties, and integration of system elements. The final product will be an easy-to-use cryogenic insulation that exhibits ultra-high insulation effectiveness and is easily applied to NASA's ground and flight cryogenic applications.

Potential Commercial Applications: Cryogenic fluids and processes are important to a wide range of industrial and commercial endeavors from food processing to fuel transport. Any advances in insulation effectiveness that are easy to implement should find ready markets. Because of current environmental concerns about the CFC-based insulation commonly used in commercial refrigeration, this system will offer an attractive insulation alternative.

***

316 SSC
92-1-13.10-0085 NAS13-558
High-Pressure, Cryogenic Liquid-Level Sensor
Blazetech Corporation
145 Highland Avenue
Winchester, MA 01890-1435
N. Albert Moussa (617-721-0085)

This project will develop a non-intrusive technique to determine liquid levels in large, cryogenic, high-pressure vessels. The basic operating principles will be investigated through analysis, tests, and the design and development of a proof-of-principle prototype. This project will also examine technical and practical issues associated with this system.

Potential Commercial Applications: This sensor can non-intrusively determine liquid levels in any storage tank, under static or dynamic conditions, over a range of pressures and temperatures. The concept is particularly well-suited for use where liquid level is not uniform, such as in aircraft, ships, and other forms of transportation.

***

317 SSC
92-1-13.10-2100 NAS13-559
Diode-Laser Liquid Level Sensor
OPTRA, Inc.
461 Boston Street
Topsfield, MA 01983-1290
Michael Hercher (508-887-6600)

This project will address the problem of measuring the level of liquid hydrogen or liquid oxygen contained in a cryogenic tank. The approach is to measure the optical path from the top of the tank to the bottom and back again. Using a diode-laser light source modulated at ≈500 MHz, the phase of the modulation of the light reflected from the bottom of the tank provides a linear measure of the height of the liquid in the tank. If the

modulation frequency is f, the refractive index of the liquid is n, and if H_o and H_L are the heights of the tank and the liquid level respectively, then the phase difference between the transmitted and return beams is $\Delta\phi=C[H_o + (n-1)H_L]/f$. This optical technique can achieve a 0.1% accuracy and offers the advantages of having the sensor outside the tank and using a double window to get the light in and out of the tank without thermal loading. The objective of Phase I is to prove the feasibility of this approach. A prototype sensor will be built and tested first on a water container at 300° K, and then on a liquid nitrogen dewar.

Potential Commercial Applications: Commercial applications include not only liquid-level sensors for cryogenic fluids but also liquid level sensors for any transparent liquid at any temperature. A large market exists for precise and non-intrusive measurement of liquid levels in gasoline storage tanks.

***

318 SSC
92-1-13.13-1127 NAS13-553
Algorithm for Measurements of Effectiveness of Corrosion Protection of Structures
Technology International, Inc.
429 West Airline Highway, Suite S
Laplace, LA 70068
Laila El-Marazki (504-652-1127)

In order to measure the potentials associated with metal structures and piping systems, an analytical model producing robust numerical algorithms will be developed for evaluating an impressed current cathodic protection system. The algorithms will use boundary measurements of potentials to provide solutions to the inverse problem of determining the conductivity of a bounded region. The algorithms will be incorporated into a software package for determinating the effectiveness of cathodic protection and for quantifying the difference between corrosion-accelerating potentials and normal non-harmful potentials. The algorithms could be used to construct diagnostic capabilities to specify which systems and structures are using different (or no) protection schemes, which are attached to protected systems, and which must be isolated to prevent accelerated deterioration of either system. The application of the software will also result in identifying alternate protection systems.

Potential Commercial Applications: This method can be used for measuring the effectiveness of the corrosion protection on underground metal structures and piping. Potential users include NASA, the oil industry, and municipalities.

***

319 MSFC
92-1-13.14-9102 NAS08-39817
Hybrid, Inductive-Capacitive Microsensor Arrays for Evaluating the Integrity of Thermal Barrier Coatings
Karta Technology, Inc.
1892 Grandstand
San Antonio, TX 78238
Satish M. Nair (512-681-9102)

A novel hybrid electromagnetic sensor array will be developed for simultaneously determining disbondments and thickness variations of thermal barrier coatings. The array consists of a series of sensors that fuse the capacitance and inductive sensing technologies into a single sensor design. The sensors are sputtered on printed circuit boards and may be miniaturized for application. Phase I will fabricate, test, evaluate, and optimize various hybrid sensor designs. The sensor will be integrated with a scanning system in Phase II to conduct the automated inspection of turbine blades and other gas turbine components where thermal barrier coatings are commonly employed.

Potential Commercial Applications: The sensor can be used in situations that require the measurement of the physical and electrical properties of dielectric layers. Such an application might arise in composite cure monitoring, where the changes in dielectric properties of the resin are used to determine the degree of cure of the composite. Another example might be the detection and characterization of defects in silicon wafers used in solid-state devices.

***

320 SSC
92-1-13.15-6970 NAS13-560
Instrumentation for Monitoring Biological Oxygen Demand and for Process Control of Wastewater Treatment Systems
Arthur Technology, Inc.
P.O. Box 1236
Fond Du Lac, WI 54936-1236
Robert M. Arthur (414-922-6970)

This project addresses the need for on-line instrumentation to monitor the effluent biological oxygen demand (BOD) of wastewater treatment plants. The project will also study how to utilize the output data from the instrument to control treatment plant processes. Wastewater treatment plants currently do not measure their biological characteristics in a timely manner. An on-line respirometer, developed, manufactured, and sold by the company, will be used to obtain the output data for both BOD and process control. Although earlier systems have attempted to monitor BOD and plant bioactivity on-line, none has been able to produce precise readings of BOD at low values (0 to 20 mg/l). Similarly, no instrument is routinely used to assist in plant process control. Phase I will develop and test the feasibility of a technology that uses respirometric data

for BOD and process control. Phase II work will ready the technology for its use at wastewater treatment plants.

Potential Commercial Applications: The potential commercial applications include monitoring BOD and bioactivity at several locations in the plant and utilizing this information for automatic control. This monitoring is desirable because of its potential to reduce plant costs by better control of aeration, wasting, and return sludge. It will also assist in reducing fines incurred through violations of discharge limits.

***

321 KSC
92-1-13.17-7110 NAS10-11987
NASA Quality-Assurance Data-Collection-Network Prototype
Sentel Corporation
1735 Jefferson Davis Highway, Suite 407
Arlington, VA 22202
Richard A. Rider (703-685-7110)

A quality assurance (QA) data-collection-network prototype will be developed for NASA based on advanced data-collection technology and configured with software tailored to support NASA spreadsheet accounting analysis requirements. The prototype will collect test data, temporarily store it, transfer it to a central PC, permit search and retrieval interactions, and generate task tracking status reports and trend analyses. In a related effort, work authorization document identification numbers will be affixed during data-collection exercises and cross-referenced back to task records within the central system. The prototype network will be an innovative combination of off-the-shelf hardware, tailored software, quality-by-design techniques, and information management practices. Phase I will meet NASA's immediate QA data collection needs. Phase II will take the prototype and use it to make for NASA a fully-developed, QA data-collection network as well as a generic data-collection approach with broad commercial applications.

Potential Commercial Applications: The prototype is applicable to any commercial operation requiring efficient data collection, organization, and analysis. Fully developed Phase II network components can be rapidly configured to meet specific and generic commercial data management applications.

***

322 KSC
92-1-13.18-2020 NAS10-11984
Bayesian Methodology for Assessing Schedule and Cost Risks for the Shuttle Orbiter Processing Facility
PLG, Inc.
4590 MacArthur Boulevard, Suite 400
Newport Beach, CA 92660-2027
Stan Kaplan (714-833-2020)

Using Bayes' theorem for quantitative risk assessment, this project will develop a methodology to systematically minimize schedule and cost risks in ground processing. This methodology will make use of all relevant, or even partially relevant, processing data in feedback-loop fashion to update a dynamic probabilistic process model that will allow the manager to see and avoid most likely delays, resource choke points, and delay costs. To demonstrate the methodology, the orbiter processing facility's processing flow will be used as a platform, following which the model will be updated using existing activity networks, software, and shop-floor data. Since all forms of data (past experience, expert opinion, and near-real-time process experience) are weighted by the methodology, the model will converge on an accurate representation of the flow in process. Managers can then use the model to take the most cost-beneficial actions that will reduce delays and costs.

Potential Commercial Applications: The Bayesian approach permits the use of all data, including engineer's judgements, to tailor the process model to reflect the true state of knowledge of the process flow and the degree of uncertainty in that knowledge. This approach will allow managers of any complex process to apply critical resources where they will do the most good and avoid committing resources in areas that are unlikely to produce savings.

***

323 KSC
92-1-13.18-4944 NAS10-11982
Integrated Risk-Analysis Tool for Schedule and Cost
Lumina Decision Systems
125 California Avenue
Palo Alto, CA 94306
Max Henrion (415-327-4944)

The goal of this project is to develop a set of innovative, computer-based methods for performing integrated risk assessment and management of schedules and costs for the space shuttle ground processing. These varied methods include hierarchical influence diagrams for integrated modeling of dependencies among task schedules and costs at multiple levels of complexity, an easy-to-use tool for probabilistic encoding of uncertainties, decision-oriented methods for rating risk factors, techniques for updating time and cost probability distributions in the light of experience, modeling of contingent schedules, and insightful displays for communicating the results. The methods would

be prototyped and evaluated by a company-developed software package that uses hierarchical influence diagrams for probabilistic modeling. The new tools would provide a fully integrated system for analyzing schedules and cost risks.

Potential Commercial Applications: These methods will provide the basis for a new kind of project management tool that uses risk analysis of scheduling and costs. There is widespread demand for such a tool, throughout industry and government, wherever there are large technical projects with uncertain schedules and costs.

***

324 KSC
92-1-13.18-6017 NAS10-11986
Risk Manager System for Space Shuttle Ground Processing
Risk Management Systems
21 East Ferry Drive
Atlanta, GA 30341
William R. Bacon (404-255-6017)

This project will seek to apply fuzzy logic concepts to in-depth subjective risk assessments of activities. Current prevailing techniques force the estimator to provide a three-point estimator (PERT) or to incorrectly assume risk factor independence (Bayesian prior probabilities) to model risk. The fuzzy expert system application transforms multiple linguistic approximations of risk factors associated with suspect underlying planning assumptions into a single best-fit three-point approximation of risk. The project's objectives are to demonstrate the feasibility of quantifying subjective risk assessments by using fuzzy set concepts and, thereby, to develop an expert system that would systematically guide decision-makers through the process of managing mission risks. This risk-assessment project has a process of capturing subjective risk assessments, can develop risk rules and facts for the expert-system knowledge base, and offers a prototype system for a specified ground process risk area. A prototype which can be used with off-the-shelf project management systems to assess and analyze real risk would work effectively because it would more accurately estimate the nature and consequences of risk to mission cost and schedule performance. Associated risk factors need not be independent, and different managers' perceptions of risk may be assessed consistently through program guidance.

Potential Commercial Applications: Risk is an important factor in every large project. Use of the system described herein for projects where risk factors are easily identified, such as construction and power plant outages, would significantly improve management control.

***

14: Satellite and Space Systems Communications

325 JSC
92-1-14.01-1291 NAS09-18848
Integrated Sensor Control and Telecommunications
Invocon
9001 I-45 South, Suite 560
Conroe, TX 77385-8703
Karl Kiefer (713-364-1291)

NASA requires a sensory network to various spacecraft systems. Sensors are located in and around the spacecraft where phenomena are to be monitored. Sensors may be either fixed or mobile. Sensors must send data from each point to a centralized terminal for use by mission managers. The sensor control and telecommunications (SCAT) system solves the problem of collecting data from groups of spatially distributed sensors while minimizing physical size, weight, power consumption, equipment cost, installation complexity, and maintenance. SCAT is a packet radio store-and-forward network (S/FN) combined with a distributed, artificially intelligent, network management (AIM) algorithm. SCAT can communicate both data and control messages between any nodes, in the network. Any network node consists of a microprocessor and radio transceiver and can interface with various analog or digital sensors. Network configuration, monitoring, and reconfiguration is handled automatically at each node by the AIM algorithm. S/FN technology removes the need for direct communication between all network nodes thereby saving radio power, size, and cost. The unique combination of this technology with the microprocessor-based AIM algorithm makes possible the creation of the ultra-small microwave sensor data collection system.

Potential Commercial Applications: The system can be used in watershed analysis, glacier ablation, passive seismic networks, microclimate definition, ocean-energy exchange dynamics, and command and control for electric power grid management.

***

326 JSC
92-1-14.01-3907 NAS09-18927
Ultra-Efficient, Ka-Band Power Monolithic Microwave Integrated Circuit
Schellenberg Association
18091 Fieldbury Lane
Huntington Beach, CA 92647
James M. Schellenberg (714-847-3907)

A 0.5 watt power monolithic microwave integrated circuit (MMIC) operating at 28 GHz with a power added efficiency of greater than 60 percent, is the goal of this project. These results will be achieved by employing high-performance pseudomorphic, high-electron-mobility transistor (PHEMT) devices in conjunction with two new circuit innovations. First, to enhance efficiency, push-pull Class B with waveforming on both the input and ouput

will be developed. Using this combination, computer simulations indicate that drain efficiencies of greater than 80 percent are possible. Second, a unique, co-planar, slot-line layout will be devised to realize this configuration. The net result is a unique combination of high-performance devices, Class B bias with wave-forming, push-pull operation, and a practical layout configuration. This work should have a major impact on the way that high-efficiency-power MMICs are designed in the future. In particular, this work should be extremely important for satellite- and spacecraft-based communication links where prime power consumption is a major concern.

Potential Commercial Applications: These MMICs can be used in satellite and spacecraft communication links, airborne active phased array radar, digital cellular telephones; and any application requiring high-efficiency microwave power.

***

327 GSFC
92-1-14.02-9411 NAS05-32443
High-Speed Diode-Laser Modules for Satellite Optical Crosslinks
Spectra Diode Laboratories, Inc.
80 Rose Orchard Way
San Jose, CA 95134
William J. Gignac (408-943-9411)

This project will design a laser module that will serve as a key component in an optical satellite crosslink. The baseline design uses a commercially available family of high-power, single-spatial-mode, diode lasers manufactured by the firm. The module integrates diode lasers with electronics for direct amplitude modulation with a goal of greater than 300 MBits/s and peak optical powers of 150 mW. Optics are included that both collimate and circularize the output beam. The module will have a clear path to space qualification and designs will be considered to accommodate future higher power diode lasers. This project will integrate the highest power, commercially available diode lasers with high-speed modulation electronics and beam-shaping optics to produce a compact source for satellite crosslink transmitters. Phase II will consist of the fabrication of the high-speed modules designed in Phase I. Successful completion of Phase II would provide the designers of the Data Relay Satellite System with a diode-laser-based optical crosslink transmitter.

Potential Commercial Applications: With the successful delivery of prototypes to NASA in Phase II, the high-power, high-speed, collimated, round beam single-mode laser will be marketed. No similar product presently exists in the commercial market. Aside from the space-borne applications which may have commercial requirements for this module, the next most likely application is high-data-rate optical read and/or write data storage systems.

***

328 JPL
92-1-14.03-0204 NAS07-1239
High-Rejection, Ultra-Lightweight Telescopes for Deep-Space Optical Communications
SSG, Inc.
150 Bear Hill Road
Waltham, MA 02154
Peter Hadfield (617-890-0204)

Deep-space optical communications require telescopes combining large aperture with ultra-light weight. Driving factors include source power limitations, receiver sensitivity, launch cost, vehicle availability, and mission utility. High off-axis, straylight rejection (OAR) to accommodate small Sun-Earth-spacecraft angles requires multi-mirror re-imaging that greatly increase the telescope's weight. The emerging silicon-carbide (SiC) technology for low-cost, high-stability, lightweight, flight optical systems offers a potential solution. This project will extend the ultra-light SiC technology to large mirrors (from the .05 - 0.1m range to the 0.5m range) having one-tenth the areal density of standard lightweighting, while minimizing the weight penalty associated with OAR. Phase I will develop a conceptual design for such a device with visible optical performance and high point-source rejection. In addition, a weight-appropriate demonstration mirror will be fabricated and tested for stability and rejection-limiting scatter. Phase II will fabricate, align, and test such a telescope for imaging properties and OAR performance. This project will result in the technology for 0.5m, high rejection telescopes that weigh less than 10 Kg and cost less than $900,000. Benefits will also be seen for optical communications in two areas: 0.3m-class telescopes for Mars and lunar orbiters and 5m ground-based receivers.

Potential Commercial Applications: The technology generated in the project can be used in flight telescopes for commercial remote sensing, deep space laser communications missions, optical communications for Mars and lunar orbiters, and ground-based optical communication receivers.

***

329 HQ
92-1-14.04-4887 NASW-4784
Low-Cost Global-Positioning System and Inertial Mapping System
Navsys Corporation
14960 Woodcarver Road
Colorado Springs, CO 80921
Alison K. Brown (719-481-4877)

This project combines an inertial instrument with the Global-Positioning System to make a GPS-inertial mapping (GIM) system that will be capable of providing

sub-meter performance even during periods of satellite shadowing. This is achieved through the use of an innovative differential-carrier-ranging (DCR) algorithm that computes a highly accurate position solution (<0.15m) when four satellites are visible. To achieve high accuracy during periods of shadowing, an innovative estimator and smoother algorithm will be developed to calibrate the inertial errors. Preliminary simulation results have demonstrated that this improves the inertial position data by more than an order of magnitude over a conventional GPS-aided Kalman filter. The combination of the DCR and estimator and smoother algorithms allows the GIM to provide sub-meter accuracy during unaided GPS operation for up to 100 seconds, using low-cost, miniaturized inertial instruments (e.g. 0.1°/√hr gyros). Phase I will provide simulation results on the DCR and estimator/smoother performance. A trade study will also be performed of suitable inertial instruments for use in Phase II. A preliminary survey has identified a candidate micro-mechanical inertial measurement unit (IMU) with a projected cost of $500 in quantities of 10,000. Phase II will integrate the selected IMU with a miniaturized GPS receiver and demonstrate the GIM system performance.

Potential Commercial Applications: The GIM system allows uninterrupted mapping data to be collected even during periods of temporary GPS signal outages. This permits highly accurate, continuous, automatic data collection to be carried out from moving vehicles. A wide variety of commercial applications exist for the GIM as a data collection system for geographic information systems (GIS).

***

330 SSC
92-1-14.04-9224 NAS13-557
Compensation of a Navigation System for Accurate Low-Cost Mapping
Envirospace Software Research, Inc.
507 Alhambra Road
Venice, FL 34285
Stephen R. Gerig (407-725-9224)

The goal of this project is to develop an integrated differential global positioning system combined with a compensated inertial navigation system (GPS-INS) for mapping applications. It will be low-cost, lightweight, compact, and accurate even when reception by the GPS receiver is blocked. The differential GPS receiver, the XR4-G of Navstar Electronics, Inc., costs about $3,000. The navigational gyroscopes, the Gyroengines of Gyration, Inc., are made of plastic, are tiny, and will, when in production, cost only several hundred dollars. To increase the accuracy of the Gyroengines for the mapping application, compensation, i.e., incremental corrections, will be applied to their raw observations. These incremental corrections will be calculated in real time by an attached notebook computer using the system error model derived in Phase I and implemented in Phase II. For NASA, the integrated GPS-INS will provide accurate, low-cost, ground-truth mapping for satellite imagery of the earth's surface.

Potential Commercial Applications: Commercial application would be in accurate, low-cost navigation, tracking, and mapping by ground-vehicles and helicopters.

***

331 LeRC
92-1-14.05-3200 NAS03-26405
Low-Cost, High-Performance Multichip Packages for Monolithic Microwave Integrated Circuits
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02154-1196
K. Jayaraj (617-890-3200)

The goal of this project is to combine the unique properties of liquid crystalline polymers (LCP) with high conductivity substrates to develop a multichip package for monolithic microwave integrated circuits (MMICs). The approach will use coplanar, wave-guide transmission lines on a barrier LCP film to provide chip-to-chip RF connections and impedance-controlled off-package transitions. The superior dielectric properties of LCPs, combined with their excellent barrier properties, make this approach feasible. Phase I will conduct design and material tradeoffs and fabricate a test structure to characterize the IC-to-interconnect and interconnect-to-board transitions and the ability of LCPs to protect ICs. In Phase II, the firm will team with Honeywell to further develop and commercialize this technology by designing, fabricating, and testing a multichip package containing several MMICs. This development will result in a low-cost, low-weight, and high-performance multichip package for packaging phased-array antennas for NASA missions such as the Mars Rover and Mission Planet Earth.

Potential Commercial Applications: This development will have specific commercial applications in receiver front-ends for direct satellite-to-home TV, in instrumentation where cost and circuit packaging density are important, and in mobile communications.

***

332 LeRC
92-1-14.05-4881 NAS03-26404
One-Picosecond, High-Impedance, Absolute-Voltage Probe and/or Pulser with One-Microwatt Sensitivity
Picotronix, Inc.
P.O. Box 130243
Ann Arbor, MI 48113-0243
Steven Williamson (313-763-4881)

This project will fabricate and characterize a new free-standing photoconductive voltage probe that has 1-picosecond temporal resolution. The probe is based on

a recently developed picosecond, high-efficiency photoswitch. The probe will have sensitivity of 1 microvolt and dynamic range greater than 10^6. Though contacting in nature, it is non-invasive with a load resistance greater than 10 Mohm and capacitance less than 1 fem to Farad. The probe will require a singular high-speed contact to the device under test and can be reversed in its role to launch a picosecond electrical pulse. The probe and/or pulser will be versatile and relatively simple to implement. This project will test the probe for speed, sensitivity, repeatability, invasiveness, and robustness, at both room and cryogenic temperatures. Phase I will also use the photoconductive probe to both launch and receive electrical signals for measuring the S-parameters of a simple two-port device. The results will be compared to measurements made with a conventional 50-ohm network analyzer.

Potential Commercial Applications: This probe will find applications in testing both analog and digital circuits. The probe will work equally well at cryogenic temperatures, permitting its use in testing high-critical-temperature superconductors and Josephson devices. Also, the ultimate spatial resolution of the probe is submicrometer for testing of future integrated circuits.

***

333 LeRC
92-1-14.05-9611 NAS03-26409
RF Components for Satellite Communications Systems--Active Phased Arrays
Epsilon Lambda Electronics Corporation
427 Stevens Street
Geneva, IL 60134
Robert M. Knox (708-232-9611)

This project addresses phased-array antenna configurations for producing multiple beams, scanned beams, and for transmitting (TX) and receiving (RX) by incorporating new emerging monolithic, multifunction chip technology into the array. When phase-shifter and TX and RX functions are incorporated directly into the array (active array), several problems arise which are exacerbated at millimeter wavelengths (30-100 GHz). First, the TX and RX functions must be isolated from each other and the radiator. Next, physical space must be found for all required component functions. Other problems include undesired radiation form-feed lines, blind beam directions caused by surface wave modes in the array substrate, heat dissipation, and the system's high cost and complexity. The firm will develop an aperture couple array (ACA) concept which will address and improve the array design in all of these problem areas. An improvement on an already published and validated ACA concept results from incorporating the now-mature fiber millimetric technology into the TX and RX and phase-shifter functions. The Phase II demonstration will provide a basis for Phase III incorporation of emerging monolithic TX and RX and phase shifter devices. A program plan for the Phase II demonstration of an active sub-array based on the validated concept will be prepared during Phase I.

Potential Commercial Applications: This large active array has potential use in various types of government communication satellites of various types which will operate in millimeter wavelengths. It is also potentially useful in commercial communication satellites for fixed and mobile services at different altitudes.

***

334 LeRC
92-1-14.06-3000 NAS03-26406
Real-Time Data Compression Using Optical Flow
Tanner Research, Inc.
180 North Vinedo Avenue
Pasadena, CA 91107
John Tanner (818-792-3000)

The project will design and deliver a data-compression scheme to support real-time transfer of video data over a limited bandwidth link. Phase I will develop a new compression algorithm based on the company's research in optical flow. Using optical flow to segment an image allows for a much more extensive use of frame-to-frame coherence. Most of the change in an image results from the sensor's motion through the environment. The new optical-flow compression algorithm analyzes the scene motion and transmits movement of patches of the scene in place of retransmitting the image. This method is suitable for any two-dimensional image transmission generated by a variety of space-based imaging sensors. During Phase I, representative video data will be collected and software will be written to demonstrate the feasibility of the new compression algorithms. The software implementation will be geared toward the Phase II implementation in VLSI hardware and delivery of a real-time compression, expansion, and display system.

Potential Commercial Applications: The new image compression algorithms and their implementation will lead to an inexpensive product with wide applicability in space, commercial, and military markets such as video phones and HDTV systems.

***

335 LeRC
92-1-14.06-9019A NAS03-26408
Error Coding and Loss Cell Recovery in Asynchronous Transfer Mode
The Consultare Group, Inc.
4853 Cordell Avenue, Suite 901
Bethesda, MD 20814
William W. Wu (301-984-9019)

This project investigates coding processors for Asynchronous Transfer Mode (ATM) in broadband ISDN (B-ISDN). Specifically, the processors will be operated at 650 Mbps, 5.0 dB gain with rates exceeding 0.75 for

the ATM Header and for the information field. With an intended cell-loss probability of 10^{-10}, a loss-cell-recovery mechanism will be provided. The scheme is based on novel multiplexing, parallel processing, and a new coding combination.

Potential Commercial Applications: B-ISDN is the guiding principle of all future telecommunications satellites and for fiber optical cables. Presently known applications include cable television, high quality or high definition television, switched multi-megabit data service (SMDS), and high-speed LAN, MAN and WAN.

***

336 LeRC
92-1-14.07-3907 NAS03-26407
Low-Cost Monolithic Microwave Integrated Circuit Receiver for Advanced Communications Technology Satellite Terminals
Schellenberg Association
18091 Fieldbury Lane
Huntington Beach, CA 92647
James M. Schellenberg (714-847-3907)

A high-performance, low-cost, 20 GHz down-converter for advanced communications technology satellite (ACTS) terminals will be developed consisting of low noise amplifier (LNA) and a mixer chip combined with separate intermediate frequency (IF) and local oscillator amplifier chips. The IF bandpass filter is realized as part of the packaging substrate. This 3-chip configuration will be packaged using multilayer, low-temperature, co-fired ceramic (LTCC) technology, resulting in a fully integrated, hermetically sealed subsystem. This approach contains several unique aspects. Low-noise, pseudomorphic, high-electron mobility transistor (HEMT) devices in the LNA to reduce the size of the antenna (less than 0.6 meter); a single chip LNA-mixer to reduce the size and cost; and multi-layer, LTCC technology to incorporate the IF bandpass filter and the bias networks into the package for reliability and cost. Further, this approach is always concerned with the manufacture of the end product.

Potential Commercial Applications: The MMIC receiver would apply to low-cost, high-performance ground terminals for ACTS, SATCOM, and direct broadcasting satellite terminal systems.

***

337 JPL
92-1-14.08-1866 NAS07-1215
Active High-Temperature Superconductor Circuits for Integrated Microwave Receivers and Antenna Arrays
Parkview Research & Development, Inc.
565 Science Drive, Suite A
Madison, WI 53711
Gert K.G. Hohenwarter (608-238-1866)

This project will explore magnetically controlled, high-temperature superconductor (HTS) thin-film circuits for applications in HTS receivers and novel array antennas with special attention given to dual-gate configurations. These types of circuits could become important building blocks for the design of monolithic superconducting microwave and millimeter-wave communications receivers aboard spacecraft. Devices to be considered are long step-edge junctions and flux-flow transistors. This project addresses the need for analysis of the device properties and its interfacing with oscillators and mixers plus distributed array antennas. The project will also make and explore device parameters to demonstrate their feasibility. Phase II will fabricate and test the mixer, mixer/oscillator/filter combinations, and antenna array prototypes. Exploration of these concepts could open the door to intermediate-frequency and low-frequency, superconducting signal processing circuits and potential applications in medical microwave imaging.

Potential Commercial Applications: These could lead to using HTS technology onboard satellites. Small and highly sensitive receiving arrays could also reduce field levels in medical microwave imaging.

***

338 JPL
92-1-14.08-7646 NAS07-1231
20 to 30 GHz Communication Links
Superconductor Technologies, Inc.
460 Ward Drive, Suite F
Santa Barbara, CA 93111-2310
Neal Fenzi (805-683-7646)

A highly integrated communications receiver in the 20 to 30 GHz frequency range will be analyzed and defined. To demonstrate its integration potential, the project will design, build and test a CPW low-noise amplifier at 30 GHz. As part of Phase II, a generic communication receiver will be designed, integrated, and packaged to realize maximum benefit from high-temperature superconductors (HTS) and cryo-cooled components. This approach will show that integration allows for low-loss, high-performance interconnects and ease of packaging and cooling. In addition, the approach will take advantage of current efforts to develop cryo-cooled, high-electron, mobility transistor amplifiers; low-loss HTS filters and antennas; and low-phase-noise, HTS stabilized oscillators.

Potential Commercial Applications: Commercial applications include high-density data links that use millimeter-wave frequencies requiring low bit-error rates with low transmit power levels and small antennas.

***

15: Materials Processing, Micro-Gravity, and Commercial Applications in Space

339 LeRC
92-1-15.01-0688 NAS03-26548
Compact Spaceflight Solution Crystal-Growth System
Metrolaser
18006 Skypark Circle, #108
Irvine, CA 92714-6428
James D. Trolinger (714-553-0688)

The goal of this project is to develop a small, instrumented, self-contained crystal growth system that will allow for greater access to microgravity than is provided by currently available crystal growth research cells. The project will make use of advanced instrumentation technology to develop a versatile, miniaturized growth-monitoring instrument which will be valuable in both space and ground experimentation. The system will be designed to make use of space shuttle in the middeck lockers and in units referred to as "GAS Cans" located in the bay. These units would require a relatively short manifest time, whereas currently available crystal research chambers can only be operated in the spacelab with years of advance planning. By incorporating knowledge gained from previous spacelab work to simplify and specialize the design, valuable microgravity time can be regularly accessed and at low cost. This new design could lead to the early commercial production of optical materials possessing properties that cannot be produced in earthbound crystal growth chambers. Phase I will produce a bench mock-up that will be used to test instrumentation concepts and determine the feasibility of implementation in the space shuttle. The work will be performed with the Alabama A&M University.

Potential Commercial Applications: This project will result in a more accessible, lower cost, solution crystal growth chamber that will greatly increase its access to microgravity for crystal production, result in commercial production in larger quantities of certain nonlinear optical materials, and produce instrumentation spin-offs that can also be used in earthbound experimentation for crystal growth.

***

340 MSFC
92-1-15.01-5693 NAS08-39823
III-V Semiconductor Infrared Bulk Materials for 8-12 Micron Range
Microgravity Research Association, Inc.
P.O. Box 10505
Midland, TX 79702
Sabya Sachi Bose (915-684-5693)

Far-infrared detectors operating in the 8 to 12 μm range of the spectrum are extremely important, but high-quality devices are very difficult to make because of problems associated with the starting materials such as HgCdTe. The objective of Phase I is to determine the potential of using Bi- and Tl- contained in InSb and $InAs_{.35}Sb_{.65}$ alloys for far-infrared applications in the 8 to 12 μm atmospheric window. Concurrently, the project will evaluate the capability of the liquid-phase, electro-epitaxy (LPEE) technology for bulk growth of these materials. The firm will use its existing LPEE equipment and standard characterization techniques. This program could lead to the development of a new and highly desirable class of IR materials that can far overshadow currently used HgCdTe. Further, the LPEE bulk crystal technique could be used for space-based experimentation where, due to gravity-driven connective flows, the microgravity environment could help the development of large diameter (3" and up) wafers.

Potential Commercial Applications: Commercial applications include sensors and/or detectors used in medical scans, earth resource monitoring, and energy conservation through scans of structures for heat loss. Military applications include detectors for mapping, tracking, intelligence functions, and terminal guidance.

***

341 LeRC
92-1-15.01-6576 NAS03-26838
Microscopic and Macroscopic Modeling of Layer Growth Kinetics and Morphology in Vapor Deposition Processing
CFD Research Corporation
3325-D Triana Boulevard
Huntsville, AL 35805
Anantha Krishnan (205-536-6576)

Physical or chemical vapor deposition processes are used increasingly to obtain solid films on substrates. Thin films grow through the adsorption of molecular species which undergo a host of surface kinetic processes, including diffusion, reaction, and nucleation, before they form the new solid. Depending on the specific interactions occurring on the surface, the resulting film morphologies range from molecularly smooth to incomplete coverage with dendritic habit. Many device applications require films that are rather smooth on a molecular level. Hence, an understanding of the conditions governing the growth of specific film morphologies is important for efficient design of vapor deposition processes. Current process modeling, however, deals almost exclusively with the macroscopic transport aspects of vapor deposition. This project involves the development of a Monte Carlo (stochastic) model to simulate the microscopic surface phenomena (of vapor growth kinetics and morphology) and the coupling of this microscopic model with an advanced macroscopic transport and reaction model. The microscopic model to be developed in Phase I will elucidate the dependence of film morphology on the energy parameters, temperature, and interfacial supersaturation. In Phase II, the microscopic model will be

incorporated into an existing, advanced macroscopic fluid-flow code and validated against experimental data.

Potential Commercial Applications: The development of a realistic model for the evolution of interfacial vapor growth morphologies will lead to a better understanding of the factors affecting the growth of thin films. This model, after coupling with the selected computational fluid dynamics (CFD) code, can be used to simulate film growth under various conditions, including microgravity.

***

342 LeRC
92-1-15.02-3800 NAS03-26551
Unstable Flow Experiments on Spacecraft
Creare, Inc.
P.O. Box 71
Hanover, NH 03755
Paul H. Rothe (603-643-3800)

Terrestrial experience teaches that multiphase systems offer advantages, such as light weight, compactness, and high performance, over single-phase pumped loops. However, multiphase systems on earth are dangerous because of their potential for unstable behavior, failure in service, and rupture, which can cause system damage and even personnel deaths. These unstable flow phenomena are further complicated by the unknown effects of microgravity, reduced gravity, and variable acceleration on the stability of multiphase systems. Phase I of the project will define which multiphase flow experiments to conduct to test the reliable operation of spacecraft multiphase flow systems. The overall objective of this project is to design critical experiments that will effectively use the testing facilities at NASA and will subsequently lead to design experiments to be performed in space. Consequently, the science of microgravity multiphase flow will be advanced, anticipating the technology risks of multiphase systems for both thermal management and other spacecraft systems.

Potential Commercial Applications: This project supports the company's plan to commercialize equipment and engineering services to NASA, DoD, and their prime contractors. It also contributes to the evaluation of terrestrial multiphase systems found in commercial facilities, including transportation of steam or petroleum products, fossil power and chemical process plants, and nuclear power stations.

***

343 MSFC
92-1-15.02-9027A NAS08-39818
Adaptive Optical Alignment in Microgravity Environments
Owen Research
810 Mohawk Drive
Boulder, CO 80303
Robert B. Owen (303-441-9027)

This project will develop a compact adaptive optical system that is able to maintain alignment in a six-degree, vibration-laden microgravity environment. A neural network controller and electronic feedback loops will be used to select and adaptively adjust optical components in up to three axes simultaneously. The specific objective is to develop a detailed prototype design for a data analysis and adaptive control algorithm that will determine and control the three most active degrees of misalignment in near-real-time. The algorithm will be used to specify off-the-shelf hardware with low-size, weight, and power requirements. Verification of the Phase II system will take place on board the NASA KC-135, low-gravity simulation aircraft.

Potential Commercial Applications: With this unit, NASA can confidently use advanced and environmentally sensitive optical methods like multi-color holography. Other possible applications include industrial process monitoring and control, and inspection and research instrumentation for commercial processes such as crystallization, separation, solute-solvent, glass, and other solidification and phase-change phenomena.

***

344 MSFC
92-1-15.03-0774 NAS08-39819
X-Ray Diffraction Camera for On-Orbit Analysis and Characterization of Crystals
Princeton Scientific Instruments, Inc.
7 Deer Park Drive
Monmouth Junction, NJ 08852
John L. Lowrance (908-274-0774)

Materials research and development in a microgravity environment is a particularly promising technology for exploiting the commercial opportunities afforded by the space environment. Protein crystal growth for structural determination and other properties is of particular interest. The large size of these protein crystals makes it difficult for them to retain their structure when they are subjected to the reentry environment's deceleration forces. For this reason, x-ray diffraction measurements require a soft x-ray image-sensor system, with high quantum efficiency and high spatial resolution over a format of up to 2000 x 2000 pixels and with digital data output. Such x-ray cameras are the state-of-the-art for ground-based protein crystallography. After addressing the requirements and problems associated with a spaceborne, x-ray diffraction camera system, Phase I will produce a conceptual design. There is a significant commercial market in

industrial and academic research for x-ray diffraction instruments, particularly the charge-coupled, device-based, x-ray camera system.

Potential Commercial Applications: X-ray diffraction imaging is becoming increasingly important in ground based materials research and biological sciences.

***

345 HQ
92-1-15.04-4260 NASW-4792
Automated Wafer Cartridge System
Advanced Modular Power Systems, Inc.
4667 Freedom Drive
Ann Arbor, MI 48108
Michael E. Dobbs (313-677-4260)

An automated wafer cartridge system (AWCS) provides low cost, modular wafer storage and manipulation, for both experimental and production quantities of ultra-high-purity materials, using the ultra-high-vacuum space environment. The AWCS is a self-contained, vacuum-sealed cartridge system that utilizes robotic mechanisms, advanced bearing materials, and automation software. It is a modular system, compatible with industry-standard wafers and processing techniques, and it will fulfill the launch and operational requirements imposed by either manned or unmanned vehicles and supervised or autonomous platforms. The development of the AWCS enable the deployment of a low-cost infrastructure. These lower costs will help induce industry to finance materials experimentation and commercially-operated materials processing in orbit. Both the reduction in unit-production cost and the high throughput generated by the AWCS will encourage supplier sector involvement so that a self-sustaining, space-based micro-material business can emerge.

Potential Commercial Applications: A commercialized AWCS can be licensed by the firm to the Space Automation and Robotics Center (SpARC), Center for the Commercial Development of Space (CCDS), and the Space Vacuum Epitaxy Center (SVEC-CCDS) for wafer production on the Wake Shield Facility (WSF) under a joint endeavor agreement between SVEC and SpARC. SpARC will fulfill the automation requirements for commercial wafer production on the WSF. The firm will also pursue AWCS commercialization via equipment suppliers to the semiconductor industry.

***

346 HQ
92-1-15.08-6000 NASW-4791
Autonomous, Small Animal, Life-Support Module
Space Industries, Inc.
101 Courageous Drive
League City, TX 77573
Jeffery Lasater (713-538-6000)

Many complications arise when small animals fly in space. Problems include accurate thermal control with varying heat loads, automatic waste collection, food and water dispensing, odors, lengthy stays on the launch pad prior to launch, and packaging constraints. A bent-fin, thermoelectric heat exchanger using "fuzzy logic control" offers an effective solution for accurate thermal control in a relatively small package. Solid and liquid waste can be effectively collected by using air ventilation and either a "rolling" filter or a mechanism devised for centrifugal separation of gas and liquid/solid constituents. A device designed to contain and dispense food pellets at a rate equal to consumption solves the problem of excessive or inadequate food distribution. A late insertion device, using a turnlock mechanism, maintains hermetic seals and simplifies procedures for late loading of the animal subjects. The project objectives are to evaluate the systems for feasibility, determine appropriate complementary subsystems, and evaluate the performance, size, and weight of a small animal life-support module. A functioning laboratory model with actual or simulated systems will be constructed to demonstrate calculated functional capabilities.

Potential Commercial Applications: Given launch capabilities, this approach offers the pharmaceutical, medical, and other science communities a cost-effective means of placing small animals or even plant life experiments in an accurately controlled environment in microgravity. Technologies and configurations developed in this effort are key to the development of a commercially viable, animal life-support module.

***

Appendix A: Description of the SBIR Program

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) program was instituted in 1982 by Public Law 97-219. P.L. 102-564, enacted in 1992, extended and strengthened the SBIR program and increased its emphasis on pursuing commercial application of SBIR project results. Implementation of the program follows policy directives issued by the Small Business Administration (SBA). Eligibility is limited to U.S.-owned companies operating primarily in the U.S. and having fewer than 500 employees at the time a contract is awarded.

Purposes

The legislated purposes of the SBIR 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 socially and economically disadvantaged persons and women in technological innovation.

SBIR Program Phases

As specified by the enabling legislation, SBIR is a three-phase R&D program. For Phase I, the objectives are to establish the feasibility and merit of an innovative scientific or technical concept proposed by a small business. Firms respond to a need or opportunity delineated by an agency in its annual Program Solicitation. Contracts for Phase I are awarded through a competitive selection process based on the evaluation of Phase I proposals submitted in response to a Solicitation.

Phase II of SBIR is the principal research and development effort. Its purpose is the further development of the proposed ideas to meet the particular program needs. Only Phase I contractors may submit proposals to continue their Phase I research into Phase II. The selection of Phase II awards considers the scientific and technical merit and feasibility evidenced by the first phase, the expected value of the research to the agency, the competence of the firm to conduct Phase II, and potential commercial applications.

In Phase III, a small business pursues commercial applications of the results of the R&D conducted under Phases I and II. Commercial applications include both government and private sector uses, and Phase III includes any activities required to develop and market commercial applications of the technology. Phase III is usually supported by private capital, but it may also include continued R&D and procurement funded by a federal agency to meet its program needs. Phase III may not be supported by SBIR funds, however.

Phase I and Phase 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 last for six months. The original funding limit--the one applicable to the projects described in this volume--was $50,000. In 1993 funding will not exceed $70,000 at NASA. Phase II contracts are for a period of 24 months. The limit in place for Phase II projects was formerly $500,000, but in 1993 the funding limit at NASA will be $600,000.

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, potential commercial

applications, and company capabilities. There are no quotas for specific technical areas. For Phase II, the Phase I results are a major factor, and cost is an important consideration. Phase II also places greater emphasis on evidence of commercial application potential than in Phase I, particularly for non-government uses. Evaluators include NASA technical staff members at the Field Centers responsible for the subtopics and NASA Headquarters program officials. NASA, at its discretion, may also use outside evaluators.

Program History

Initiated in 1982, 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 a specified percentage of NASA's annual budget for R&D contracting. For Fiscal Year 1992, 1.25 percent, or $79 million, was provided to the NASA SBIR program. The legislated SBIR set-aside increased to 1.5 percent in Fiscal Year 1993, bringing NASA's SBIR program funding to $99 million. NASA SBIR program funding for all years of the program amounts to almost $527 million. Thus far 2,159 Phase I and 919 Phase II awards have been made. Since the NASA budget supports, in large part, the accomplishment of dedicated mission and R&D goals and has limited flexibility in the optional use of these specifically budgeted funds, the SBIR program constitutes a significant portion of the agency's research effort.

Small businesses have responded vigorously to the opportunities presented by the SBIR program. The number of Phase I proposals has grown from 977 in 1983 to 2870 in 1993. Awards have been made to 979 firms in 42 states, the District of Columbia, and Puerto Rico. Approximately 18 percent of the firms submitting proposals have received Phase I awards, and about 52 percent of those firms have received Phase II continuations. 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 intention that at least half of the Phase I projects proceed into Phase II.

Appendix B: 1992 Topics and Subtopics

01 Aeronautical Propulsion and Power
- 01.01 Internal Fluid Mechanics for Aeropropulsion Systems
- 01.02 Aeropropulsion System Components
- 01.03 Aeropropulsion System Instrumentation, Sensors, and Controls
- 01.04 Novel Aeropropulsion Concepts and Analytical Methods

02 Aerodynamics and Acoustics
- 02.01 Computational Fluid Dynamics
- 02.02 Flow Physics Modeling and Control
- 02.03 Hypersonic Vehicle Aerothermodynamics
- 02.04 High-Angle-of-Attack and High-Lift Configurational Aerodynamics
- 02.05 Unsteady Aerodynamics and Aircraft Dynamics
- 02.06 Rotorcraft Aerodynamics and Dynamics
- 02.07 Wind Tunnel Design and Experimental Techniques
- 02.08 Wind Tunnel Instrumentation
- 02.09 Aircraft Noise Prediction and Reduction
- 02.10 Propulsion Noise Reduction

03 Aircraft Systems, Subsystems, and Operations
- 03.01 Aircraft Icing Protection Systems
- 03.02 Aircraft Weather Environment
- 03.03 Control Concepts for Fixed Wing Aircraft
- 03.04 Fully Automatic Guidance for Rotorcraft
- 03.05 Flight Research Sensors and Instrumentation
- 03.06 Aircraft Flight Testing Techniques
- 03.07 Hypersonic Flight Systems Technology
- 03.08 Very-High-Altitude Aircraft Technology
- 03.09 Aeronautical Human Factors and Flight Management
- 03.10 Testing and Verification of Flight-Critical Systems
- 03.11 Aerospace Vehicle Flight-Characteristics Simulation

04 Materials and Structures
- 04.01 Coatings on Fibers for Ceramic and Intermetallic Composites
- 04.02 Processing of High-Temperature Composites
- 04.03 Computational Structural Methods for Aeropropulsion
- 04.04 Computational Methods for Aeropropulsion Materials Processing
- 04.05 Cyclic Oxidation Behavior of Materials for Aeropropulsion
- 04.06 Adaptive Control Techniques for Fabricating and Testing Metallic Materials
- 04.07 Oxidation-Resistant, Carbon-Carbon Composites for Aerostructures
- 04.08 Nondestructive Evaluation of Material Properties
- 04.09 Alloys for Space Propulsion Systems
- 04.10 Lubricants for Aeronautics and Space Applications
- 04.11 High-Performance Polymers for Aircraft Applications
- 04.12 Composite Materials for Aircraft and Space Applications
- 04.13 Adaptive, Smart Aerospace Structural Components and Materials
- 04.14 Space Structure Dimensional Stability
- 04.15 Active Truss Strut for Interferometric Applications
- 04.16 Spacecraft Structures and Mechanisms for Manned Spacecraft
- 04.17 Space Mechanical Components
- 04.18 Special Purpose Materials for Space Applications
- 04.19 Materials to Withstand Space Environmental Effects
- 04.20 An Analytical Tool for Inflatable Antenna Structures
- 04.21 Castable Aluminum and Magnesium Matrix Composites
- 04.22 Joining Polymeric and Metallic Composite Components
- 04.23 Thermal Protection Materials and Systems
- 04.24 Vacuum Plasma Spray Forming
- 04.25 Bonding Techniques for High-Temperature Components
- 04.26 Low-Temperature Extrusion Material With Ceramic Reinforcement
- 04.27 Welding Technology
- 04.28 High Temperature Superconductors
- 04.29 In Situ Materials Processing and Utilization
- 04.30 Nondestructive Monitoring of Composite Materials

05 Teleoperators and Robotics
- 05.01 Mission Support Flight Robotics
- 05.02 Supervised Autonomous Intelligent Robotic Systems for Manned Space Missions
- 05.03 Intelligent Robotic Operations
- 05.04 Neural Networks and Fuzzy Logic for Robotic Systems
- 05.05 Space Robotic Mechanisms
- 05.06 Robotic Surrogates for Human Grasping and Manipulation
- 05.07 Telerobotic Displays, Non-Visual Sensing, and Controls

06 Computer Sciences and Applications
- 06.01 Computational Advances for Aerospace Applications
- 06.02 Software Support Systems for Unmanned Missions
- 06.03 Reliable Software Development

Appendix C: Index of 1992 Phase I Projects By State

Appendix D: Index of Participating Companies

A

B

C

Coherent Technologies, Inc.
Boulder, CO 80306
033: Monitoring Weather Effects on Aircraft Wakes Using a Solid-State Coherent Lidar
134: Using a Solid-State Coherent Lidar for Precision Inflight Measurement of Turbulent Air Motion

Coleman Research Corporation
Orlando, FL 32819
107: Advanced, Coherent Laser-Radar-System Components

Colorado Engineering Research Laboratory, Inc.
Fort Collins, CO 80525
063: Atomic-Oxygen Resistant Tribo-Surfaces

Command Control, Inc.
Atlanta, GA 30350
308: Improved Lightning Forecast for Kennedy Space Center

Compiere, Inc.
Palo Alto, CA 94302
019: Simultaneous Density and Velocity Measurements in Hypersonic Flow
020: Measurement of Aerobrake Model Forces and Flow Fields

Composite Optics, Inc.
San Diego, CA 92121
142: Thermally Stable, Large-Aperture, High-Resolution Optics

Computer Optics, Inc.
Hudson, NH 03051
184: Optical Sensor Calibration by the Touchstone Technique

Conductus, Inc.
Sunnyvale, CA 94086
156: High-Temperature Superconductor, Yttria-Stabilized, Zirconia Membrane Bolometer
161: Inductive Sensing for a Superconducting Membrane Bolometer at 90 Kelvin

Continuum Dynamics, Inc.
Princeton, NJ 08543
029: Computational Methods for Rotor Transonic, Aeroacoustic-Aeroelastic Analyses

Cordec Corporation
Lorton, VA 22079-0188
069: Vapor Deposited, Metal-Matrix Composites for Dimensional Stability without Hysteresis

Creare, Inc.
Hanover, NH 03755
002: Advanced Software for Soot Modelling
217: A Quick-Disconnect Cryogenic Joint
218: High-Performance, Regenerative Sorption Compressor Element
219: Miniature, Cryogenic Turboalternator
231: Micromachined Evaporator for Wicked AMTEC Cells
342: Unstable Flow Experiments on Spacecraft

Crystal Association, Inc.
Waldwick, NJ 07463
138: Synthesis and Crystal Growth of New Nonlinear Optical Materials in the System $KTiOPO_4$-$CsTiOPO_4$

CSA Engineering, Inc.
Palo Alto, CA 94303-3843
221: Adaptive Vibration Suppression Mount for Cryogenic Coolers

Cullimore & Ring Technologies, Inc.
Littleton, CO 80127
203: Cryogenic, Capillary, Pumped Loop
207: Real-Time, Graphical, Thermal-Fluid System Simulation

Cybernet Systems Corporation
Ann Arbor, MI 48105
105: Whole Arm and Hand-Finger Force Reflecting Masters

D

Daat Research Corporation
Lyme, NH 03768
003: Advanced Computational Fluid Dynamics Tools for Design of Combustors and Nozzles
054: Computational Fluid Dynamics Tools for Parametric Studies in Materials Processing

Data Parallel Systems, Inc.
Bloomington, IN 47408
128: A Query System for Heterogeneous, Distributed Database Management Using a Massively Parallel Hyper-Index

Deacon Research
Palo Alto, CA 94303
028: Miniature Laser Velocimeter
222: Compact, Real-Time Sensor for Non-Volatile Residues

Digiray Corporation
San Ramon, CA 94583
058: Augmented Penetrating Capability for Reverse Geometry X-Ray®System

Direct Current-Light
Lawndale, CA 90260
297: Low-Cost Inventory Management and Crew-Tracking System

Displaytech, Inc.
Boulder, CO 80301
303: Miniature High-Resolution Display

Dove Electronics, Inc.
Rome, NY 13440
126: Electro-Optical and Optical Nodes for Integrated Data Systems

Dynacs Engineering Company, Inc.
Palm Harbor, FL 34684
093: Control of a Flexible Manipulator During Re-Orientation of the Payload

Dynaflow, Inc.
Fulton, MD 20759
014: A Pseudo-Spectral Mapping Technique for the Accurate Solution of Viscous Flows in Complex Geometries

Dynatherm Corporation
Cockeysville, MD 21030
205: Bubble Tolerant Capillary Pumps

E

E/J Bloom Association, Inc.
San Rafael, CA 94903-2317
241: Planar, Integrated-Magnetic Power Components

EGR Association
Buffalo, NY 14221
034: Integrated Criteria and Synthesis for Multivariable Flight Control

EIC Laboratories, Inc.
Norwood, MA 02062
243: Near-Ambient Solid-Polymer Fuel Cell
261: Modulation of Solar Momentum for Satellite Attitude Control
288: Solid-State Microionic Oxygen Sensor for Closed, Environmental Life-Support Systems

Electrochem, Inc.
Woburn, MA 01801
242: High-Efficiency, Proton-Exchange-Membrane Fuel Cell for Near-Ambient Operation

Electrochimica Corporation
Redwood City, CA 94063
239: Safe, High Energy Aqueous Batteries for Manned Applications

Electroformed Nickel, Inc.
Corona, CA 91720
256: Improved Electroformed Structural Copper and Copper Alloys for Rocket Components

EMCORE Corporation
Somerset, NJ 08873
158: Low-Temperature Fabrication of Barium-Strontium-Titania Films for Room-Temperature Infrared Detectors

EMEC Consultants
Export, PA 15632
091: Vacuum Separation of Oxides for Lunar Processing to Produce Metals and Oxygen
233: Advanced Electrode Materials for Silver-Metal-Hydride Batteries

Energy Optics, Inc.
Las Cruces, NM 88001
296: Computer-Operated, Nictating Telemetry, Remote-Operation and Lightweight System

Energy Science Laboratories, Inc.
San Diego, CA 92121-2232
208: Carbon Brush Heat Exchanger

Engineering Sciences, Inc.
Huntsville, AL 35805
244: A Fast Algorithm for Transient All-Speed Flows and Finite-Rate Chemistry
249: Comprehensive Model for Combustion Instability in Liquid Propellant Rocket Engines

Enig Association, Inc.
Silver Spring, MD 20705-2633
018: High-Resolution Solutions to Stiff, Chemically Reacting Flow Fields

Environmental Optical Sensors, Inc.
Boulder, CO 80302
179: Stabilized Diode Laser for Laser Metrology

Envirospace Software Research, Inc.
Venice, FL 34285
330: Compensation of a Navigation System for Accurate Low-Cost Mapping

Epsilon Lambda Electronics Corporation
Geneva, IL 60134
333: RF Components for Satellite Communications Systems - Active Phased Arrays

ERC, Inc.
Tullahoma, TN 37388
117: A Knowledge-Based System Developer for Aerospace Applications

Essex Corporation
Orlando, FL 32803
266: A Methodological Approach to Improving Pre-flight Adaptation Training
292: Cognitive and Performance Readiness of Space Crews

Excel Superconductors, Inc.
Bohemia, NY 11716
157: Infrared-Transmissive, Diamond-Like Carbon Films for Protecting High-Temperature Superconducting Detectors

Exfluor Research Corporation
Austin, TX 78758
062: Novel Additives for Perfluoropolyether Lubricants

Eyetech Corporation
Iowa City, IA 52240
295: HeadMouse: A Head Direction, User-Computer Interface

F

Fastman, Inc.
Bethlehem, PA 18018
129: Fractal and/or Wavelet Real-Time Image Compression

Fed Corporation
Research Triangle Park, NC 27709
211: Field-Emitter Display Development for Workstations

Femtometrics
Costa Mesa, CA 92627
188: A 200 MHz Surface-Acoustic-Wave Resonator Micro-Deposition Monitor

Fiber Materials, Inc.
Biddeford, ME 04005-4497
263: Lightweight, Oxidation Resistant, High-Temperature Composite Thrusters

Fibertek, Inc.
Herndon, VA 22070
133: Advanced, Diode-Pumped, Cavity-Dumped Laser for Space-Based Altimetry

Flow Analysis, Inc.
Brooklyn, NY 11212
024: A Unified Numerical Approach for Rotorcraft Aerodynamics

Fluent, Inc.
Lebanon, NH 03766
001: Advanced Turbulence Models on Unstructured Triangular Meshes

Fluorochem, Inc.
Azusa, CA 91702
074: Elastomeric Polyimides

Foster-Miller, Inc.
Waltham, MA 02154-1196
042: Lightweight-High Strength PBO Structures for High Altitude Subsonic Aircraft
106: Truss Climbing Robot
227: Lightweight Graphite-Aluminum Space Radiators for Thermal Management
253: High Reliability, Low-Cost RTM Preforms for Solid Rocket Motor Nozzles
279: Resistance Heating of Zeolites and Silica Gels for the Removal of Carbon Dioxide and Water Vapor
331: Low-Cost, High-Performance Multichip Packages for Monolithic Microwave Integrated Circuits

Front Range Scientific Computation, Inc.
Denver, CO 80217-3364
109: A C** Virtual, Shared-Grid Model for Architecture-Independent Programming

Fusion Systems Corporation
Rockville, MD 20855
283: Efficient, Full-Spectrum, Long-Lived, Non-Toxic Lamp for Plant Growth

G

Garman Systems, Inc.
Getzville, NY 14068
198: Unobtrusive Sensor and Effector Technology with Optical Applications

Gemtech Microwaves, Inc.
Acworth, GA 30102
060: Advanced Microwave Imaging Techniques for Materials Processing and Monitoring

Geo-Centers, Inc.
Newton Centre, MA 02159
285: Selective Ligand Surfaces for Nutrient Solution Monitoring and Control
286: Carbon-Dioxide Monitoring System for CELSS Applications

Giner, Inc.
Waltham, MA 02154
215: Electrochemical Compressor to Recover Hydrogen Boil-Off Gas from Cryogenic Tanks

Gumbs Association, Inc.
East Brunswick, NJ 08816
186: Hydrogen-Chloride Sensor Based on Conducting Polymers

H

High Technology Corporation
Hampton, VA 23666
016: Transition Prediction and Laminar Flow Control in Compressible Three-Dimensional Boundary Layers Using Parabolized Stability Equations

HiTc Superconoco
Lambertville, NJ 08530
088: A Pinning-Phase Purification Process to Produce Useful Bulks of High Temperature Superconductors

Honeybee Robotics
New York, NY 10012
103: A Cableless Joint for Space Robotic Manipulators

Horizon Technology, Inc.
Ravenna, OH 44266
078: Ultraviolet-Heat Cure Structural Adhesives

Hot Enterprises
Golden, CO 80401
075: Fullerene-Based Thermal Control Coatings for Space Structures

Huntsville Sciences Corporation
Huntsville, AL 35806
247: Low-Cost Analysis Tool for Concurrent Engineering Applications

Hyper-Therm, Inc.
Huntington Beach, CA 92648
047: High-Temperature, Oxidation-Resistant Fiber Coating for Toughened Ceramic-Matrix Composites

Hypres, Inc.
Elmsford, NY 10523
150: High-Resolution, Ultra-Low Power, Superconducting, Analog-to-Digital Converter
153: Wide-Dynamic-Range, Digital, Superconducting Quantum Interference Device Amplifiers for Multiplexing and Readout of Cryogenic Detector Arrays

I

Illinois Superconductor Corporation
Evanston, IL 60201
087: High-Performance, Superconductor, Thick Films for Sensors and Detectors

Imitec, Inc.
Schenectady, NY 12301
065: Synthesis of Reactive Toughening Polymers Based on NASA Langley Research Center Thermoplastic Polyimides

Implant Sciences Corporation
Wakefield, MA 01880
210: Increased Lifetime Electroluminescence Phosphors

Innovative Dynamics, Inc.
Ithaca, NY 14850-1252
092: Development of an Integrated Health Monitoring System for Composite Structures

J

K

L

M

Maine Research & Technology Company
Cambridge, MA 02139-0902
281: Sterilization of Drinking Water on Human Planetary Missions

Materials & Electrochemical Research
Tucson, AZ 85706
057: Innovative Oxidation Protection Systems for Carbon-Carbon Composites Materials and Electrochemical Research
237: A Novel, Negative, Hydride Electrode for Nickel-Metal-Hydride Batteries
301: Fullerene Hydrides Cooling System for Extra-Vehicular Activities

Matrix Science, Inc.
Richland, WA 99352
229: Indium-Phosphide Solar Cells Grown on Zinc-Selenide-Coated Silicon Substrates

Meadowlark Optics, Inc.
Longmont, CO 80504-9470
148: Construction of a Liquid-Crystal Tunable Filter for Visible Light

Membrane Technology & Research, Inc.
Menlo Park, CA 94025
276: Water Treatment by a Pervaporation Removal of Gas and Volatile Organic Compounds

Metrolaser
Irvine, CA 92714-6428
339: Compact Spaceflight Solution Crystal-Growth System

Micracor, Inc.
Concord, MA 01742
132: Q-Switched, Diode-Pumped, Microchip Laser Arrays for Laser Altimetry

Micro Composite Materials Corporation
Research Triangle Park, NC 27709
061: Porous Refractory Carbides Made of Discontinuous Fibers for Beamed-Energy Propulsion Systems

Microgravity Research Association, Inc.
Midland, TX 79702
340: III-V Semiconductor Infrared Bulk Materials for 8-12 Micron Range

Microsensor Systems, Inc.
Bowling Green, KY 42103
187: Surface Acoustic Wave Device as Micro Deposition Sensor

Modar, Inc.
Natick, MA 01760
287: Supercritical Water Oxidation of Inedible Biomass

Modulus Technologies, Inc.
Houston, TX 77030
098: Distributed, Autonomous Robotics Integration System for Space Applications

Moltech Corporation
Stony Brook, NY 11794-2800
235: Novel Polymer Electrolytes for Lithium Rechargeable Batteries
311: Compact Laser Microprobe Mass Spectrometer

MRJ, Inc.
Oakton, VA 22124
052: Massively Parallel Computational Methods Augmented with Neural Net Technology for Structural Analysis and Design

MSNW, Inc.
San Marcos, CA 92079
048: Multifunctional Interface Coatings for Sapphire Monofilaments

N

Nastec, Inc.
Cleveland, OH 44114
095: High-Performance, Programmable, Compliant Manipulators

Navsys Corporation
Colorado Springs, CO 80921
329: Low-Cost Global-Positioning System and Inertial Mapping System

Nektonics, Inc.
Cambridge, MA 02139
124: A Computational Fluid Dynamics Package for Massively Parallel Supercomputing

Nemo Filters
Mountain View, CA 94043
160: Beamsplitters Which Operate from the Far Infrared to Millimeter Wavelengths

Neurodyne, Inc.
Boston, MA 02116
010: Enhanced Performance Seeking Control Using Neural-Network-Based State Estimation
194: Integrated Control System for Aerospace Plane Using Stochastic Nonlinear Optimal Control

New Horizons Diagnostics
Columbia, MD 21045
268: System for Rapid Detection of Microbial Contamination in Water

New Light Industries, Limited
Spokane, WA 99204
121: Improved Genetic Algorithm for Plan Scheduling and Optimization
123: High-Resolution, High-Speed, Spatial Light Modulator

Nielsen Engineering & Research, Inc.
Mountain View, CA 94043-2287
015: Advanced Discretization Algorithm for Computational Fluid Dynamics Methods
046: An Unsteady Aerodynamics Model Based on Indicial Theory for Multidisciplinary Flight Simulations
110: A Knowledge-Based System for Analyzing Technical Data

Nomadic Technologies
Palo Alto, CA 94306
212: A Flexible, Artificial Intelligence Testbed

O

Omnitech Robotics, Inc.
Littleton, CO 80127
100: Mini-Robot Rover

Optiphase, Inc.
Van Nuys, CA 91406
036: Aircraft-Based Fiber Optic Environmental Sensor Network
178: Low-Noise, Fiber-Optic Gyro for Inertial Reference Applications

Optivision, Inc.
Palo Alto, CA 94304
200: Packaging of Opto-Electronic Integrated Circuits for Space-Based Applications

OPTRA, Inc.
Topsfield, MA 01983-1290
027: High-Temperature, Fiber-Optic Pressure Sensor
317: Diode-Laser Liquid Level Sensor

Orbital Technologies Corporation
Madison, WI 53719
090: Carbothermal Reduction of Lunar Materials for Oxygen Production on the Moon
257: Metalized-Cryogen for Advanced Hybrid Engines

Osmotek, Inc.
Corvallis, OR 97339
274: Direct Osmotic Concentration of Waste Water

Ovonic Battery Company
Troy, MI 48084
236: High-Energy-Density, Nickel-Metal-Hydride Batteries

Owen Research
Boulder, CO 80303
343: Adaptive Optical Alignment in Microgravity Environments

P

Parkview Research & Development, Inc.
Madison, WI 53711
337: Active High-Temperature Superconductor Circuits for Integrated Microwave Receivers and Antenna Arrays

PCB Piezotronics, Inc.
Depew, NY 14043-2495
067: High-Power-Density Piezoelectric Actuator for Noise and Vibration Reduction

PDA Engineering
Costa Mesa, CA 92626
255: Effective Porosity of Rayon-Based Carbon-Phenolics

Perceptual Images
Los Gatos, CA 95032
108: Autosteroscopic Video Monitor for Computer Graphics

Photon Research Association, Inc.
Cambridge, MA 02138
223: Man-Machine Interaction Models for Advanced Spacecraft and Robotic Applications

Photonic Systems, Inc.
Melbourne, FL 32901-2625
122: Analog Optical Vector-Matrix Computer
183: A Simultaneous, Electronically Variable, Multi-Spectral Imaging System

Physical Optics Corporation
Torrance, CA 90501
059: Embeddable Distributed Moisture Sensor for Nondestructive Inspection of Aircraft Lap Joints
141: A Spectroscopic Imaging Sensor Using Parallel Pixel Filtering
146: Fiber-Optic Sensor for Low-Level Humidity Measurement in the Upper Atmosphere
214: Aeolian Tone Flow Meter Using Optical Fiber
293: Three-Dimensional Displays with A 360° View for Space Crew

Physical Sciences, Inc.
Andover, MA 01810
038: Compact Diode-Laser-Based Inlet and Exhaust Mass-Flow Flight Instrument
089: Optical Waveguide Solar Energy System for Lunar Material Processing
145: A Disposable Optical Ozonesonde for Airborne Stratospheric and Tropospheric Ozone Measurements by Small Balloons
167: A Compact, Vacuum Ultraviolet Light Source Based Upon Dielectric-Barrier Discharge Technology
224: Evaluation of Plume Impingement Effects
246: Optical Diagnostics for Solid Rocket Motor Nozzles

Physics Innovations, Inc.
St Paul, MN 55121-1767
213: Polarization-Sensitive, Thermal Imaging Sensors

Picotronix, Inc.
Ann Arbor, MI 48113-0243
332: One-Picosecond, High-Impedance, Absolute-Voltage Probe and/or Pulser with One-Microwatt Sensitivity

Plasma Process
Huntsville, AL 35802
082: Innovative Plasma Nozzle Techniques for Eliminating Overspray

PLG, Inc.
Newport Beach, CA 92660-2027
322: Bayesian Methodology for Assessing Schedule and Cost Risks for the Shuttle Orbiter Processing Facility

Polar Spring Corporation
Menlo Park, CA 94025
277: Water Polishing by Directional Freeze Crystallization

Q

R

S

Sensors Unlimited, Inc.
Princeton, NJ 08540
159: An Infrared Focal Plane Array with User-Selectable Spectral Response
176: High-Power, Single-Mode Diode Lasers for 2 to 5 μm
181: A Rugged, Compact, Near-Infrared Reflectance Spectrometer

Sentel Corporation
Arlington, VA 22202
321: NASA Quality-Assurance Data-Collection-Network Prototype

Siegmund Scientific
Antioch, CA 94509
155: Intensified Imager for Detection of Ultraviolet and Particles

Sievers Instruments, Inc.
Boulder, CO 80301
290: Reagentless Oxidation Reactor for Total Organic Carbon Analyzer

Smart Ceramics
Woburn, MA 01801
081: Structural Ceramic-Composite Insulation - Fiber Reinforced

Software Productivity Solutions, Inc.
Indialantic, FL 32903
114: System for Effective Evaluation of Requirements

Space Hardware Optimization Technology, Inc.
Floyd Knobs, IN 47119
306: Biotechnology Instrumentation for the Support of Embryogenesis

Space Industries, Inc.
League City, TX 77573
346: Autonomous, Small Animal, Life-Support Module

Space Instruments, Inc.
Encinitas, CA 92024
136: Quantum-Well Cloud Sensor

Spec, Inc.
Boulder, CO 80301
009: An Optical Instrument to Measure Liquid Water Content and Droplet Spectra in Clouds

Spectra Diode Laboratories, Inc.
San Jose, CA 95134-1356
127: Individually Addressable Array of Blue Laser Sources
140: High-Power, Visible, Semiconductor Laser Diodes for Solid-State Laser Pumping
164: A Dual, Diode-Pumped, Difference-Frequency, Mixing Source of 3 to 5 μm Radiation
180: Visible Laser Diodes Operating from 0.45 to 0.7 μm
327: High-Speed Diode-Laser Modules for Satellite Optical Crosslinks

Spectral Sciences, Inc.
Burlington, MA 01803-5169
250: Mixing Efficiency Diagnostic Using Spectroscopic Analysis
312: Diode-Laser Hydrazine Monitor

Spire Corporation
Bedford, MA 01730-2396
169: Compact and Reliable Vacuum Ultraviolet Radiation Source
170: Oblique-Angle, Ion Beam Sputtering for Mirror Finishing and Polishing
189: Feedback-Controlled, MetalOrganic-Chemical-Vapor-Deposition Reactor for the Indium-Gallium-Arsenic-Phosphorus Materials System

SSG, Inc.
Waltham, MA 02154
025: Imaging Radiometer for the Characterization of Boundary Layer Phenomena
172: Ultra-Lightweight, Silicon-Carbide Mirrors for Cryogenic Infrared and Sub-Millimeter Reflectors and Grazing Incidence Applications
328: High Rejection, Ultra-Lightweight Telescopes for Deep-Space Optical Communications

Standard International, Inc.
Torrance, CA 90503
102: Multi-Sensory, Feature Recognition Networks for Space Robotics

Stirling Technology Company
Richland, WA 99352
206: Low Temperature, Stirling Cycle Refrigerator for Spacecraft Refrigeration Systems
220: Integral Stirling and Joule-Thomson Cryocooler for Low Temperature Applications
228: Multi-Hundred-Watt, Stirling Technology Demonstrator for Space Power

Stress Engineering Services, Inc.
Houston, TX 77041-1101
216: Cryogenic Quick-Disconnect Seals
302: Piezoelectric Water Pump for Use in Extra-Vehicular Activities

Strickler Optical Technology, Inc.
Ithaca, NY 14850
305: Multi-Layered Optical Data Storage

Sudormed, Inc.
Santa Ana, CA 92705
273: Non-Invasive Assessment of Exercise Metabolic Responses by Analysis of Sweat Lactate

Superconductor Technologies, Inc.
Santa Barbara, CA 93111-2310
338: 20 to 30 GHz Communication Links

Swales & Association, Inc.
Beltsville, MD 20705
193: Robust Control Design by Q-Parameterization
204: Microcomputer-Based Spacecraft Thermal Analysis Software

T

TACAN Corporation
Carlsbad, CA 92008
289: Fiber-Optic Immunoassay Sensor for Monitoring Life-Support Systems

Tanner Research, Inc.
Pasadena, CA 91107
334: Real-Time Data Compression Using Optical Flow

Technology Development Association, Inc.
Wayne, PA 19087-1803
076: Novel Material Concepts for Improved Spacecraft Debris Protection

Technology International, Inc.
Laplace, LA 70068
044: A Flexible Integrated Visual Display for Flight Management
318: Algorithm for Measurements of Effectiveness of Corrosion Protection of Structures

Telerobotics International, Inc.
Knoxville, TN 37931
094: Real-Time, Video Perspective Modification for Effective Cancellation of Communication Time Delay in Vehicle Teleoperation

The Consultare Group, Inc.
Bethesda, MD 20814
335: Error Coding and Loss Cell Recovery in Asynchronous Transfer Mode

The Technology Partnership
Grosse Ile, MI 48138
071: High-Reliability, Long-Term Lubricator

Thermacore, Inc.
Lancaster, PA 17601
209: Passive, Modular, Heat-Driven Heat Pump for Lunar and Martian Explorations
265: Porous Cathode for Alkali Propellant MPD Thrusters

Tini Alloy Company
San Leandro, CA 94577
072: A Low-Cost, Compact, Non-Explosive Pin Puller for Aerospace Applications

Tomorrowtools
Huntsville, AL 35824
294: VIRUPS - Virtual Reality Ultrasonic Positioning System

Triton Systems, Inc.
Marlborough, MA 01752
050: An Innovative Process for Fully Dense, High-Performance, Ceramic-Matrix Composites
064: Processing of High-Performance Poly(Arylene Ether Benzimidazole)

Truax Engineering, Inc.
Carlsbad, CA 92008
258: Engine Design and Testing of Metalized Propellants

Turbulence Prediction Systems
Boulder, CO 80301
032: Detection of Wake Vortices at Airport Runways
037: Airborne, Remote Sensing of Turbulent Air Motion

U

Ultramet
Pacoima, CA 91331
004: Cooled Porous Ceramic Vane for High Temperature Turbine Engine Components
079: Oxidation-Resistant Coating of Diboride-Composite Thermal Protection System
262: Small Composite Combustion Chambers

Umpqua Research Company
Myrtle Creek, OR 97457-0118
270: Microwave Sterilizable Access Port

V

Vigyan, Inc.
Hampton, VA 23666-1325
012: Multidimensional Wave Models for Solution-Adaptive Grid Generation
021: A Leading Edge Extension Blowing Concept for Enhanced High-Alpha and Post-Stall Aerodynamics of Highly Maneuverable Configurations

W

Western Environmental Technology Laboratories, Inc.
Philomath, OR 97370
165: A Combined Optical Property Sensor for In Situ Characterization of Ocean Waters

Winzen International, Inc.
San Antonio, TX 78249
226: A System for the Control of Balloon-Lifting Gas Temperature

Y

Yardney Technical Products, Inc.
Pawcatuck, CT 06379
234: Lithium-Ion Rechargeable Battery System with Sulfur-Dioxide-Based Electrolyte
238: High-Energy-Density, Rechargeable, Nickel-Zinc Cells with Improved Cycle Life

Appendix E: Index of Principal Investigators

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Z

Appendix F : Index of Projects Managed By Each NASA Center

Ames Research Center

Goddard Space Flight Ctr

Jet Propulsion Laboratory

Johnson Space Center

089	92-1-04.29-0003
090	92-1-04.29-1992A
091	92-1-04.29-3260C
095	92-1-05.02-1555
096	92-1-05.02-4222
097	92-1-05.02-4222A
098	92-1-05.02-9546
104	92-1-05.06-0402
105	92-1-05.06-2567
115	92-1-06.03-6871
116	92-1-06.04-7979
118	92-1-06.05-5700
119	92-1-06.05-5700B
120	92-1-06.05-7979
121	92-1-06.05-8321
128	92-1-07.04-8100
207	92-1-09.10-0292
208	92-1-09.10-2034
209	92-1-09.10-6551A
210	92-1-09.11-0700
211	92-1-09.11-9118
212	92-1-09.12-7700
213	92-1-09.13-3284
238	92-1-10.08-1100A
239	92-1-10.08-2699
262	92-1-11.09-0236
263	92-1-11.09-5911
266	92-1-12.01-5090A
267	92-1-12.01-8492
268	92-1-12.01-9357
269	92-1-12.02-2484
270	92-1-12.02-7770
271	92-1-12.02-7831
272	92-1-12.02-9806
276	92-1-12.04-2228A
277	92-1-12.04-2852
278	92-1-12.04-3149
290	92-1-12.06-2009
291	92-1-12.07-2567
292	92-1-12.07-5090A
297	92-1-12.10-5801
298	92-1-12.10-8100
299	92-1-12.10-8152
300	92-1-12.11-0540
302	92-1-12.11-2900
303	92-1-12.11-8933
304	92-1-12.12-1112
305	92-1-12.12-6465
314	92-1-13.06-1910
325	92-1-14.01-1291
326	92-1-14.01-3907

Kennedy Space Center

283	92-1-12.05-0300
285	92-1-12.05-7070
286	92-1-12.05-7070A
288	92-1-12.05-9450
307	92-1-13.01-0054
308	92-1-13.01-8430
309	92-1-13.02-1355
310	92-1-13.02-3633
311	92-1-13.03-7565
312	92-1-13.04-4770
313	92-1-13.04-7831
315	92-1-13.08-5058
321	92-1-13.17-7110
322	92-1-13.18-2020
323	92-1-13.18-4944
324	92-1-13.18-6017

Langley Research Center

016	92-1-02.02-0818
019	92-1-02.03-5630B
020	92-1-02.03-5630D
023	92-1-02.05-7093
025	92-1-02.07-0204
026	92-1-02.07-7093
027	92-1-02.08-2100
028	92-1-02.08-6100
029	92-1-02.09-9282
032	92-1-03.02-8157B
033	92-1-03.02-8736
034	92-1-03.03-0249
035	92-1-03.03-3474
036	92-1-03.05-0997
040	92-1-03.07-2620
041	92-1-03.07-2900
045	92-1-03.09-1457
055	92-1-04.06-4015
056	92-1-04.07-1100A
057	92-1-04.07-1980
058	92-1-04.08-1510
059	92-1-04.08-3088
060	92-1-04.08-4691
061	92-1-04.09-3535
064	92-1-04.11-6636
065	92-1-04.11-9101
066	92-1-04.12-5058
067	92-1-04.13-0001
068	92-1-04.13-9647
087	92-1-04.28-0435
088	92-1-04.28-2010A
106	92-1-05.07-3200
107	92-1-05.07-9200
110	92-1-06.01-9457
113	92-1-06.03-1219
114	92-1-06.03-3370
126	92-1-07.03-0230
127	92-1-07.03-9411
134	92-1-08.02-8736
135	92-1-08.03-6250
138	92-1-08.05-0060
139	92-1-08.05-3772
140	92-1-08.05-9411A
194	92-1-09.03-9106
196	92-1-09.05-0540
197	92-1-09.05-1500

Lewis Research Center

001	92-1-01.01-2600
002	92-1-01.01-3800
003	92-1-01.01-8145
004	92-1-01.02-0236
005	92-1-01.02-0540A
006	92-1-01.02-5094
007	92-1-01.01-6576
008	92-1-01.03-0900
009	92-1-01.03-1105
010	92-1-01.03-9106
011	92-1-01.04-1122
030	92-1-02.10-7070
031	92-1-03.01-0202
047	92-1-04.01-7143
048	92-1-04.01-9471
049	92-1-04.02-4626
050	92-1-04.02-6636
051	92-1-04.03-0018
052	92-1-04.03-0700
053	92-1-04.04-6627
054	92-1-04.04-8145
062	92-1-04.10-3812
071	92-1-04.17-8295
072	92-1-04.17-9676
214	92-1-09.14-3088
215	92-1-09.14-7270
227	92-1-10.01-3200
228	92-1-10.01-4000A
229	92-1-10.02-1795
230	92-1-10.02-5992
233	92-1-10.05-3260
240	92-1-10.09-7501
242	92-1-10.11-3383
256	92-1-11.05-4707
258	92-1-11.06-5888
259	92-1-11.06-9500
261	92-1-11.08-9450
331	92-1-14.05-3200
332	92-1-14.05-4881
333	92-1-14.05-9611
334	92-1-14.06-3000
335	92-1-14.06-9019A
336	92-1-14.07-3907
339	92-1-15.01-0688
341	92-1-15.01-6576
342	92-1-15.02-3800

Marshall Space Flight Ctr

063	92-1-04.10-5940
075	92-1-04.19-7520
076	92-1-04.19-9669
082	92-1-04.24-7572
085	92-1-04.26-6881
086	92-1-04.27-8600
093	92-1-05.01-4035
094	92-1-05.01-5600
141	92-1-08.06-3088
142	92-1-08.06-6000
143	92-1-08.06-7990
144	92-1-08.06-8211
170	92-1-08.15-6000D
171	92-1-08.15-8112
173	92-1-08.16-6357
198	92-1-09.06-0520
199	92-1-09.06-0540
206	92-1-09.09-4000
216	92-1-09.15-2900
217	92-1-09.15-3800
224	92-1-09.20-0003
225	92-1-09.20-8581
244	92-1-11.01-0660
245	92-1-11.01-2008A
246	92-1-11.02-0003
247	92-1-11.02-4747
248	92-1-11.02-6576
249	92-1-11.03-0660
250	92-1-11.03-4770
251	92-1-11.03-6576
252	92-1-11.04-1756
253	92-1-11.04-3200
254	92-1-11.04-4015
255	92-1-11.04-8900B
260	92-1-11.07-2246
275	92-1-12.04-1483
279	92-1-12.04-3200
280	92-1-12.04-3291
282	92-1-12.04-7505
294	92-1-12.09-0769
295	92-1-12.09-1142
296	92-1-12.09-4561
319	92-1-13.14-9102
340	92-1-15.01-5693
343	92-1-15.02-9027A
344	92-1-15.03-0774

Stennis Space Center

184	92-1-08.24-2116
185	92-1-08.24-2650
186	92-1-08.25-9049
316	92-1-13.10-0085
317	92-1-13.10-2100
318	92-1-13.13-1127
320	92-1-13.15-6970
330	92-1-14.04-9224

NASA Headquarters

078	92-1-04.22-2227
187	92-1-08.26-0099
190	92-1-08.28-7780
191	92-1-08.28-9806
243	92-1-10.11-9450
257	92-1-11.06-1992B
329	92-1-14.04-4887
345	92-1-15.04-4260
346	92-1-15.08-6000

Appendix G: Index of Projects By Contract Number

NAS1: Langley Research Center

NAS01-19869	040	03.07-2620
NAS01-19870	056	04.07-1100A
NAS01-19871	068	04.13-9647
NAS01-19872	134	08.02-8736
NAS01-19873	107	05.07-9200
NAS01-19874	020	02.03-5630D
NAS01-19875	041	03.07-2900
NAS01-19876	066	04.12-5058
NAS01-19877	035	03.03-3474
NAS01-19878	033	03.02-8736
NAS01-19879	019	02.03-5630B
NAS01-19880	029	02.09-9282
NAS01-19881	138	08.05-0060
NAS01-19882	058	04.08-1510
NAS01-19883	034	03.03-0249
NAS01-19884	088	04.28-2010A
NAS01-19885	065	04.11-9101
NAS01-19886	061	04.09-3535
NAS01-19887	028	02.08-6100
NAS01-19888	126	07.03-0230
NAS01-19889	106	05.07-3200
NAS01-19890	087	04.28-0435
NAS01-19891	197	09.05-1500
NAS01-19892	194	09.03-9106
NAS01-19893	110	06.01-9457
NAS01-19894	027	02.08-2100
NAS01-19895	059	04.08-3088
NAS01-19896	113	06.03-1219
NAS01-19897	196	09.05-0540
NAS01-19898	045	03.09-1457
NAS01-19899	036	03.05-0997
NAS01-19900	067	04.13-0001
NAS01-19901	055	04.06-4015
NAS01-19902	135	08.03-6250
NAS01-19903	139	08.05-3772
NAS01-19904	114	06.03-3370
NAS01-19905	140	08.05-9411A
NAS01-19906	025	02.07-0204
NAS01-19907	032	03.02-8157B
NAS01-19908	127	07.03-9411
NAS01-19909	064	04.11-6636
NAS01-19917	016	02.02-0818
NAS01-19918	023	02.05-7093
NAS01-19919	026	02.07-7093
NAS01-19920	057	04.07-1980
NAS01-19993	060	04.08-4691

NAS2: Ames Research Center

NAS02-13688	046	03.11-9457
NAS02-13730	038	03.06-0003
NAS02-13731	037	03.05-8157
NAS02-13732	039	03.06-0540
NAS02-13769	287	12.05-7071
NAS02-13770	284	12.05-2650
NAS02-13771	160	08.11-1548
NAS02-13772	147	08.07-9500
NAS02-13774	274	12.04-1297
NAS02-13775	164	08.13-9411
NAS02-13776	301	12.11-1980
NAS02-13777	273	12.03-0778
NAS02-13778	281	12.04-5628
NAS02-13779	122	06.06-8181
NAS02-13780	044	03.09-1127
NAS02-13781	021	02.04-1400
NAS02-13782	042	03.08-3200
NAS02-13784	123	06.06-8321
NAS02-13785	024	02.06-2021
NAS02-13786	043	03.08-8457
NAS02-13787	293	12.08-3088
NAS02-13787	146	08.07-3088
NAS02-13788	117	06.04-9915
NAS02-13789	022	02.04-3304
NAS02-13794	015	02.01-9457
NAS02-13795	079	04.23-0236
NAS02-13796	014	02.01-3688
NAS02-13797	012	02.01-1400A
NAS02-13798	018	02.03-4471
NAS02-13799	017	02.03-2299
NAS02-13800	080	04.23-1729
NAS02-13801	013	02.01-1700
NAS02-13802	109	06.01-4807
NAS02-13803	081	04.23-9224
NAS02-13805	108	06.01-4562
NAS02-13809	306	12.13-9591
NAS02-13812	145	08.07-0003
NAS02-13815	163	08.13-1330

NAS3: Lewis Research Center

NAS03-26404	332	14.05-4881
NAS03-26405	227	10.01-3200
NAS03-26405	331	14.05-3200
NAS03-26406	334	14.06-3000
NAS03-26407	336	14.07-3907
NAS03-26408	335	14.06-9019A
NAS03-26409	333	14.05-9611
NAS03-26548	339	15.01-0688
NAS03-26551	342	15.02-3800
NAS03-26716	008	01.03-0900
NAS03-26717	007	01.01-6576
NAS03-26718	006	01.02-5094
NAS03-26719	031	03.01-0202
NAS03-26720	030	02.10-7070
NAS03-26721	242	10.11-3383
NAS03-26722	228	10.01-4000A
NAS03-26723	005	01.02-0540A
NAS03-26834	072	04.17-9676
NAS03-26838	341	15.01-6576
NAS03-26839	051	04.03-0018
NAS03-26840	048	04.01-9471
NAS03-26841	004	01.02-0236
NAS03-26842	052	04.03-0700
NAS03-26843	049	04.02-4626
NAS03-26844	071	04.17-8295
NAS03-26846	053	04.04-6627
NAS03-26847	062	04.10-3812
NAS03-26848	054	04.04-8145
NAS03-26849	050	04.02-6636
NAS03-26850	047	04.01-7143
NAS03-26904	002	01.01-3800
NAS03-26905	009	01.03-1105
NAS03-26906	233	10.05-3260
NAS03-26907	240	10.09-7501
NAS03-26908	229	10.02-1795
NAS03-26909	230	10.02-5992
NAS03-26911	010	01.03-9106
NAS03-26912	001	01.01-2600
NAS03-26913	003	01.01-8145
NAS03-26914	259	11.06-9500
NAS03-26915	214	09.14-3088
NAS03-26916	261	11.08-9450
NAS03-26917	215	09.14-7270
NAS03-26918	256	11.05-4707
NAS03-26919	258	11.06-5888
NAS03-26929	011	01.04-1122

NAS5: Goddard Space Flight Center

NAS05-32400	130	07.06-7978
NAS05-32401	111	06.02-4881
NAS05-32402	084	04.25-3230
NAS05-32403	201	09.07-1100B
NAS05-32404	152	08.10-1100
NAS05-32405	192	09.02-0092
NAS05-32406	112	06.02-8817
NAS05-32407	083	04.25-0655
NAS05-32408	166	08.14-6522
NAS05-32409	137	08.04-8442
NAS05-32410	175	08.17-6484
NAS05-32411	073	04.18-5058
NAS05-32412	156	08.10-6700
NAS05-32413	219	09.17-3800
NAS05-32414	221	09.17-7351
NAS05-32415	203	09.08-0292
NAS05-32416	222	09.18-6100
NAS05-32417	205	09.08-7500
NAS05-32418	158	08.10-9090A
NAS05-32419	179	08.20-7786A
NAS05-32420	157	08.10-8278A
NAS05-32421	133	08.01-7671
NAS05-32422	074	04.18-6714
NAS05-32423	103	05.05-0661B
NAS05-32424	153	08.10-1190
NAS05-32425	168	08.15-3661
NAS05-32426	154	08.10-1859
NAS05-32427	202	09.07-4545
NAS05-32428	177	08.20-0755
NAS05-32429	125	07.02-3223
NAS05-32430	237	10.07-1980
NAS05-32431	132	08.01-2114
NAS05-32432	124	07.02-0101
NAS05-32433	178	08.20-0997
NAS05-32434	200	09.07-0200
NAS05-32435	236	10.07-1750
NAS05-32436	223	09.19-1522
NAS05-32437	167	08.15-0003A
NAS05-32438	151	08.10-0774
NAS05-32439	131	08.01-1896
NAS05-32440	155	08.10-4759
NAS05-32441	136	08.04-7001
NAS05-32442	180	08.20-9411
NAS05-32443	327	14.02-9411
NAS05-32444	169	08.15-6000A
NAS05-32445	220	09.17-4000
NAS05-32446	204	09.08-5500
NAS05-32447	193	09.02-5500
NAS05-32448	165	08.14-5650
NAS05-32449	226	09.21-3400

NAS7: Jet Propulsion Laboratory

NAS07-1205	099	05.03-0402
NAS07-1206	148	08.08-4068
NAS07-1207	218	09.16-3800
NAS07-1208	176	08.18-0610
NAS07-1209	182	08.21-7200
NAS07-1210	189	08.27-6000
NAS07-1211	069	04.14-8044
NAS07-1212	195	09.04-0092
NAS07-1213	162	08.12-4538
NAS07-1214	070	04.15-2407
NAS07-1215	337	14.08-1866
NAS07-1216	231	10.03-3800
NAS07-1217	092	04.30-0533
NAS07-1218	234	10.06-1100
NAS07-1219	150	08.09-1190
NAS07-1220	102	05.04-4511
NAS07-1221	077	04.20-0771
NAS07-1222	183	08.22-8181
NAS07-1223	235	10.06-7565B
NAS07-1224	265	11.10-6551A
NAS07-1225	241	10.10-8443
NAS07-1226	101	05.03-9570
NAS07-1227	161	08.11-6700
NAS07-1228	188	08.26-6239
NAS07-1229	149	08.08-8958
NAS07-1230	181	08.21-0610
NAS07-1231	338	14.08-7646
NAS07-1232	159	08.11-0610
NAS07-1233	289	12.06-1010
NAS07-1234	129	07.05-2577
NAS07-1235	264	11.10-3772
NAS07-1236	100	05.03-7830
NAS07-1237	232	10.03-5992
NAS07-1238	174	08.16-7990
NAS07-1239	328	14.03-0204
NAS07-1240	172	08.16-0204

NAS8: Marshall Space Flight Center

NAS08-39800	063	04.10-5940
NAS08-39801	076	04.19-9669
NAS08-39802	082	04.24-7572
NAS08-39803	085	04.26-6881
NAS08-39804	086	04.27-8600
NAS08-39805	094	05.01-5600
NAS08-39806	143	08.06-7990
NAS08-39807	244	11.01-0660
NAS08-39808	206	09.09-4000
NAS08-39809	216	09.15-2900
NAS08-39810	224	09.20-0003
NAS08-39811	245	11.01-2008A
NAS08-39812	248	11.02-6576
NAS08-39813	251	11.03-6576
NAS08-39814	252	11.04-1756
NAS08-39815	282	12.04-7505
NAS08-39816	294	12.09-0769
NAS08-39817	319	13.14-9102
NAS08-39818	343	15.02-9027A
NAS08-39819	344	15.03-0774
NAS08-39820	170	08.15-6000D
NAS08-39821	173	08.16-6357
NAS08-39822	260	11.07-2246
NAS08-39823	340	15.01-5693
NAS08-39824	075	04.19-7520
NAS08-39825	093	05.01-4035
NAS08-39826	142	08.06-6000
NAS08-39827	171	08.15-8112
NAS08-39828	199	09.06-0540
NAS08-39829	217	09.15-3800
NAS08-39830	225	09.20-8581
NAS08-39831	247	11.02-4747
NAS08-39832	249	11.03-0660
NAS08-39833	255	11.04-8900B
NAS08-39834	279	12.04-3200
NAS08-39835	296	12.09-4561
NAS08-39836	198	09.06-0520
NAS08-39837	141	08.06-3088
NAS08-39838	246	11.02-0003
NAS08-39839	250	11.03-4770
NAS08-39840	254	11.04-4015
NAS08-39841	275	12.04-1483
NAS08-39842	295	12.09-1142
NAS08-39843	280	12.04-3291
NAS08-39844	253	11.04-3200
NAS08-39845	144	08.06-8211

NAS9: Johnson Space Center

NAS09-18828	118	06.05-5700
NAS09-18829	121	06.05-8321
NAS09-18830	266	12.01-5090A
NAS09-18831	115	06.03-6871
NAS09-18832	292	12.07-5090A
NAS09-18833	304	12.12-1112
NAS09-18834	298	12.10-8100
NAS09-18835	291	12.07-2567
NAS09-18836	090	04.29-1992A
NAS09-18837	272	12.02-9806
NAS09-18838	314	13.06-1910
NAS09-18839	116	06.04-7979
NAS09-18840	262	11.09-0236
NAS09-18841	213	09.13-3284
NAS09-18842	211	09.11-9118
NAS09-18843	277	12.04-2852
NAS09-18844	208	09.10-2034
NAS09-18845	210	09.11-0700
NAS09-18846	238	10.08-1100A
NAS09-18847	207	09.10-0292
NAS09-18848	325	14.01-1291
NAS09-18849	120	06.05-7979
NAS09-18850	302	12.11-2900
NAS09-18851	269	12.02-2484
NAS09-18852	300	12.11-0540
NAS09-18853	128	07.04-8100
NAS09-18854	278	12.04-3149
NAS09-18855	105	05.06-2567
NAS09-18856	104	05.06-0402
NAS09-18857	212	09.12-7700
NAS09-18858	303	12.11-8933
NAS09-18859	290	12.06-2009
NAS09-18860	239	10.08-2699
NAS09-18861	097	05.02-4222A
NAS09-18862	271	12.02-7831
NAS09-18863	270	12.02-7770
NAS09-18864	268	12.01-9357
NAS09-18865	089	04.29-0003
NAS09-18866	091	04.29-3260C
NAS09-18867	267	12.01-8492
NAS09-18868	299	12.10-8152
NAS09-18869	095	05.02-1555
NAS09-18870	119	06.05-5700B
NAS09-18871	297	12.10-5801
NAS09-18872	263	11.09-5911
NAS09-18926	098	05.02-9546
NAS09-18927	326	14.01-3907
NAS09-18928	209	09.10-6551A
NAS09-18929	276	12.04-2228A
NAS09-18930	305	12.12-6465
NAS09-18931	096	05.02-4222

NAS10: Kennedy Space Center

NAS10-11973	315	13.08-5058
NAS10-11974	309	13.02-1355
NAS10-11975	310	13.02-3633
NAS10-11976	308	13.01-8430
NAS10-11977	288	12.05-9450
NAS10-11978	283	12.05-0300
NAS10-11979	286	12.05-7070A
NAS10-11980	285	12.05-7070
NAS10-11981	307	13.01-0054
NAS10-11982	323	13.18-4944
NAS10-11983	311	13.03-7565
NAS10-11984	322	13.18-2020
NAS10-11985	313	13.04-7831
NAS10-11986	324	13.18-6017
NAS10-11987	321	13.17-7110
NAS10-11988	312	13.04-4770

NAS13: Stennis Space Center

NAS13-553	318	13.13-1127
NAS13-554	185	08.24-2650
NAS13-555	186	08.25-9049
NAS13-556	184	08.24-2116
NAS13-557	330	14.04-9224
NAS13-558	316	13.10-0085
NAS13-559	317	13.10-2100
NAS13-560	320	13.15-6970

NASW: NASA Headquarters

NASW-4782	078	04.22-2227
NASW-4783	187	08.26-0099
NASW-4784	329	14.04-4887
NASW-4787	190	08.28-7780
NASW-4788	243	10.11-9450
NASW-4789	257	11.06-1992B
NASW-4791	346	15.08-6000
NASW-4792	345	15.04-4260
NASW-4796	191	08.28-9806