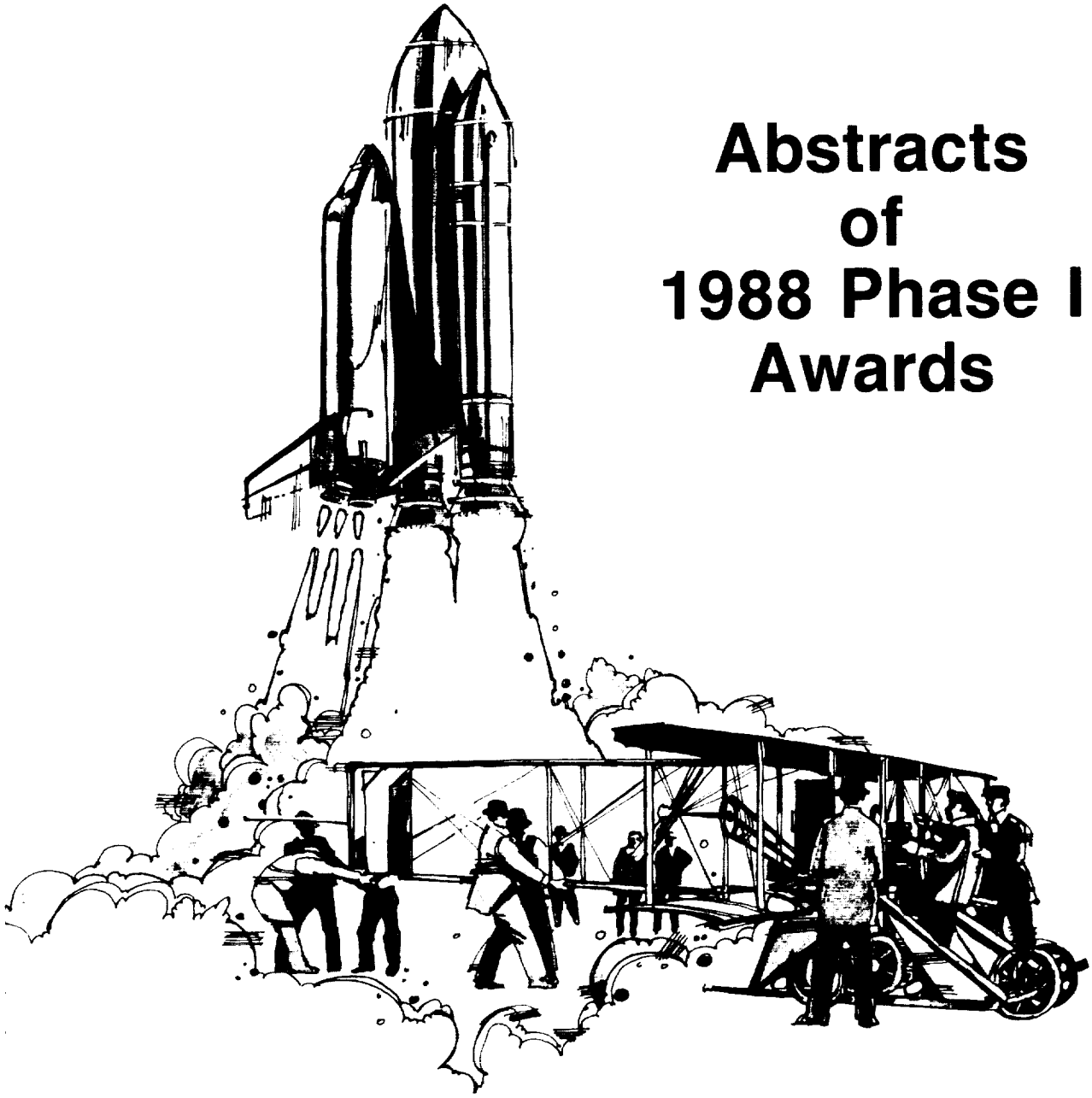
Small Business Innovation Research



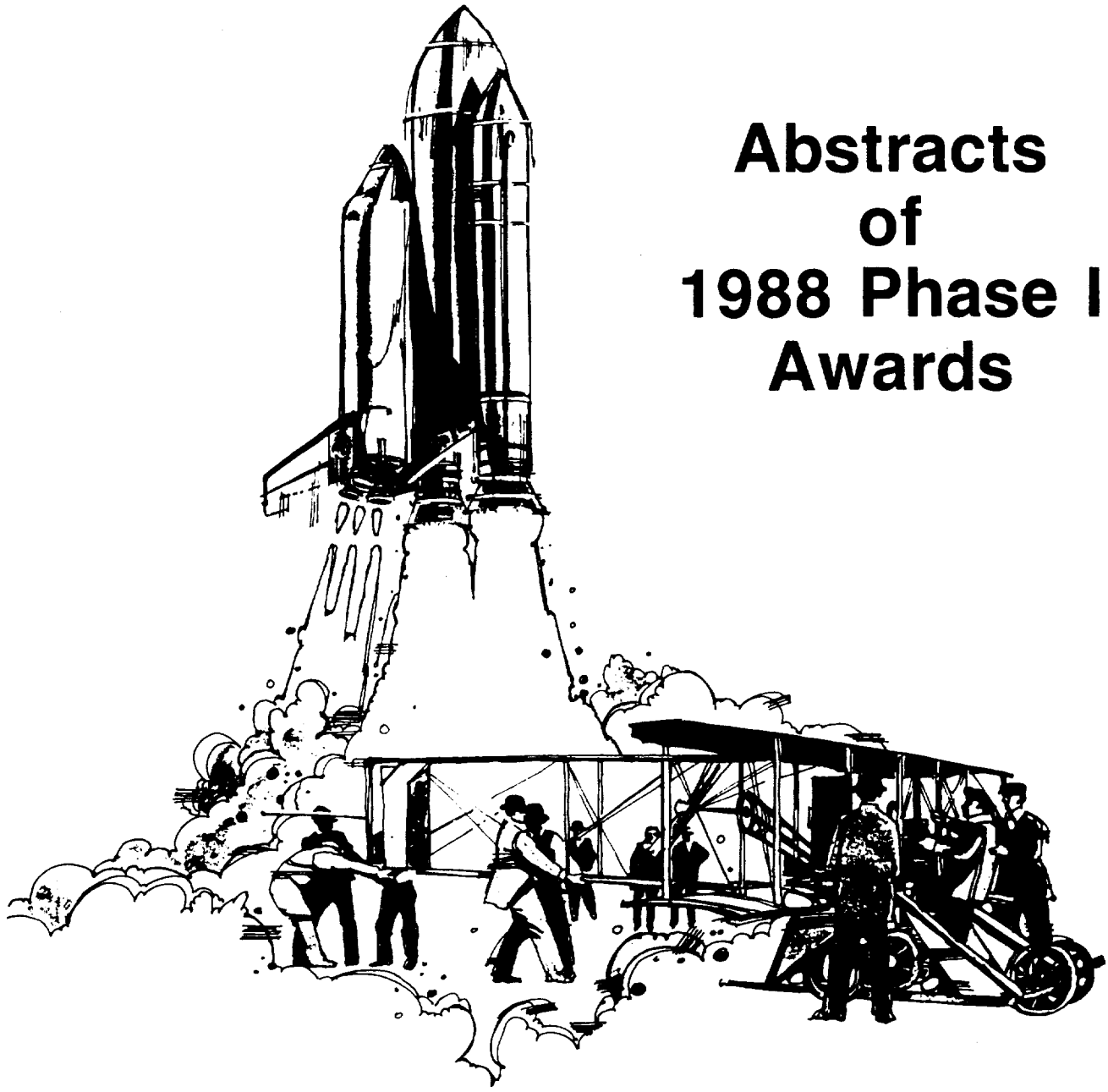
Abstracts of 1988 Phase I Awards

NASA

March 1990

SBIR PROGRAM
WASHINGTON, D.C.
20546

Small Business Innovation Research



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Prepared for the Small Business Innovation Research Office, Office of Commercial Programs, National Aeronautics and Space Administration, by F.C. Schwenk and J.A. Gilman of TEM Associates.

INTRODUCTION

This document contains non-proprietary proposal abstracts of the set of Phase I Small Business Innovation Research (SBIR) projects supported by the National Aeronautics and Space Administration (NASA) as part of the 1988 Program Year. Activities associated with a Program Year encompass all Phase I projects which result from an annual Program Solicitation and the Phase II projects subsequently selected for continuation. The appendices provide background information on the SBIR program, statistics on NASA's program to date, the technical topic and subtopic areas in which proposals were solicited in 1988, and information about the award selection process. The five indexes contain listings through which cross-references may be made for projects, companies, their locations by state, the NASA Field Center responsible for each project's management, and the principal investigator for each one. For simplicity, each project has been assigned a sequential identifying number, from 001 to 228, in ascending order as found in the body of the report.

The objective of this report is to provide information about the SBIR program to anyone concerned with NASA R&D activities including managers of NASA projects, prime contractors who could benefit from the research conducted through SBIR, industrial concerns and investors who may support further development and marketing of the results of SBIR projects, and small business firms that may wish to submit SBIR proposals and need information on the types of projects of interest to NASA. The information in the abstracts was supplied by the participating small business companies and has been issued by NASA solely for the purpose of information exchange. NASA does not guarantee its accuracy or validity. Readers are encouraged to contact the small businesses for further information or clarification.

The closing date for the 1988 SBIR Program Solicitation was July 22, 1988, at which time NASA had received 2379 Phase I proposals from small business firms. After the evaluation and selection processes were completed, NASA announced on December 7,1988 that 228 proposals had been chosen to receive six-month Phase I contract awards. Following completion of contract negotiations early in 1989, contracts for these projects were placed with 186 different small R&D firms located in 28 states.

Initiated in 1983, the NASA SBIR program has been supporting innovative R&D projects of interest to the agency and the aerospace community with funds set aside from the agency's research and development budget. Since Fiscal Year 1986, as required by law, that funding set-aside has been 1.25 percent of NASA's annual budget for extramural R&D. For Fiscal Year 1989, $53 millions have been provided to the NASA SBIR program resulting in a total of $208 millions for all years of the program to date. Since the NASA budget supports, in large part, the accomplishment of dedicated mission and R&D goals and has limited flexibility in the optional use of these specifically budgeted funds, the SBIR program constitutes a significant portion of the agency's discretionary research effort.

Program management is provided by the SBIR Program Office in the NASA Headquarters Office of Commercial Programs. The proposals are evaluated by nine NASA Field Centers who also let the contracts and manage individual projects. The following Centers are responsible for implementing the NASA SBIR program:

- **ARC** Ames Research Center, Moffet Field, CA 94035
- **GSFC** Goddard Space Fight 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, AL 35812
- **SSC** Stennis Space Center, MS 39529

PRESENTATION OF PROJECT RESULTS

The main body of this document presents edited proposal abstracts of 228 Phase I SBIR awards arising from the 1988 Program Solicitation. The order of 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.

Each technical topic contains a number of subtopics which specify the problems or opportunities to which the small business 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 1988 included the 150 subtopics listed in Appendix B.

The information provided for each of the projects includes the name and address of the firm that performed the work, the name of the principal investigator, the NASA Center which monitored the contract, and a brief summary of results of the Phase I contract and the potential commercial application of the proposed innovation identified by the contractor. The format for presenting the information for each project is as shown below:

* 360 <———— Serial Number (* indicates Phase II selection)
Project Number+ ———> 88-1-04.07-1234
Title ———> **Oxidation Resistant Alloy Coatings for Aerospace Propulsion**
Systematic Materials, Inc. <———— Company Name
678 Butter Lane
Brewer, PA 94043-1467
Jacob K. Steinkampf (215-444-1234) <———— Principal Investigator
NASA Center ———> LeRC-- NAS3-56578 <———— Contract Number
Abstract ———> This project will investigate novel alloy formulations that recent research has shown...

+ *Note: Project Number is composed of the program year (88), the topic and subtopic numbers (04.07), and an identifying number (1234).*

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 since one purpose of this publication is to enable interested parties to contact researchers directly.

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ABSTRACTS OF NASA SBIR 1988 PHASE I AWARDS

01 AERONAUTICAL PROPULSION AND POWER

* 001
88-1-01.01-1515
Numerical Modelling of Turbulence and Combustion Processes
Cambridge Hydrodynamics, Inc.
P.O. Box 1403
Princeton, NJ 08542
A. Yakhot (609-683-1515)
LeRC -- NAS3-25604

This project endeavors to develop a three-dimensional computer code based on renormalization-group (RNG) differential transport models for turbulent, heat, mass, and momentum transfer and combustion processes in strongly non-stationary, strongly separated, internal flows. Preliminary results of applying these novel models to non-stationary and separated flows, including flow over a backward-facing step, oscillatory pipe flow, and shock-induced separation on an airfoil, suggest that the models will be very effective for this class of difficult flows. In addition, recent extensions of the RNG method give a description of turbulent combustion that promises significant advances in modelling these complex problems.

Potential Commercial Applications: Applications would be in numerical modelling of complex internal flows of propulsion systems.

***

002
88-1-01.01-1708A
Efficient Computation of Viscous Internal Flows
Propulsion Research Associates
1017 Oakwood Drive
Westmont, IL 60559
S. P. Vanka (312-654-1708)
LeRC -- NAS3-25573

Numerical computation of detailed, multi-dimensional, fluid-flow processes is important for design and understanding the performance of propulsion devices. The solution of the time-averaged, Navier-Stokes equations governing elliptic fluid flows (with recirculations) presents a challenging task and requires substantial amounts of computational time. The innovation in this project is a new numerical tool based on a number of novel computational techniques that hitherto have been applied to solve very simple model problems. The techniques proposed are: multi-grid cycling, coupled solvers, local mesh refinement, and vectorization. This approach holds promise of obtaining efficient and accurate numerical solutions that can be free of finite-difference errors and yet be affordable from the viewpoint of computational costs. Under Phase I of the project, the applicability and benefits of these techniques will be demonstrated. The development and validation of the computer program would be performed Phase II.

Potential Commercial Applications: The savings possible for industries which would use the proposed accurate, low-cost computer program for routine design calculations of multidimensional flows translate into significant commercial potential.

***

* 003
88-1-01.02-0731
Gas Turbine Combustor for Low Pattern Factor and Low NOx Emission
SOL-3 Resources, Inc.
76 Beaver Road
Reading, MA 01867
Jerry O. Melconian (617-942-0731)
LeRC -- NAS3-25563

An innovative annular combustor configuration for aircraft and other gas turbine engines is based on a variable-residence-time concept. The design allows large fuel particles adequate time to completely burn in the circumferentially mixed primary zone and has the potential of permitting higher turbine inlet temperature by reducing the pattern factor and providing a major reduction in NOx emission. High durability of the combustor is achieved by use of the incoming air for dual functions. The experimental and analytical efforts of this project are aimed at predicting the performance of this novel combustor and comparing it with that of a state of the art combustor currently being designed for an engine of 10 lb/sec air flow. A major gas turbine engine manufacturer and a world renowned authority on combustion will support the design and development efforts required for this project.

Potential Commercial Applications: The combustor concept is applicable to all gas turbine engines for commercial and military aircraft.

***

004
88-1-01.03-0690A
Fiber-Optic, Fluid-Flow Sensor
Aurora Optics, Inc.
1777 Walton Road - Suite 408
Blue Bell, PA 19422
Laurence N. Wesson (215-646-0690)
LeRC -- NAS3-25619

The objective of this project is to develop and demonstrate a fiber-optic, fluid-flow sensor that will lead to all-optical, flight-data and engine-control

instruments for high performance aircraft. By mounting a photo-elastic pressure sensor on the side of a vortex-swirl flow housing, pressure pulses may be sensed. The pressure-pulse frequency is a linear function of flow rate in a vortex swirl meter. The pressure sensor is a device partially developed under a 1986 NASA SBIR Phase I contract which has been applied to vortex swirl flow measurements by the company's personnel. This project, however, will create a passive optical device, addressed solely by optical fibers, which will utilize the firm's existing generic electronic interface unit. The resulting flow meter will be tested over a range of flow rates determined in consultation by NASA and over a range of temperatures from -55 °F to +150 °F.

Potential Commercial Applications: Commercial applications are in military or commercial aircraft instrumentation for measurement of fuel-flow rate, air flow, and airspeed.

***

* 005
88-1-01.03-5709A
Silicon Carbide MOSFETs for High-Temperature, Small-Signal Amplifiers
Cree Research, Inc.
2810 Meridian Parkway, Suite 176
Durham, NC 27713
John W. Palmour (919-361-5709)
LeRC – NAS3-25607

Silicon carbide possesses properties that allow operation of electronic devices at high-temperatures: a theoretical maximum operating temperature of 925 °C for cubic-SiC (beta) and 1240 °C for alpha-SiC (6H). Both forms, having high breakdown electric fields (ten times that of Si and GaAs), allow high-power operation. Recent research has demonstrated depletion-mode, metal-oxide-semiconductor, field-effect transistors (MOSFETs) in β-SiC with good characteristics at temperatures as high as 650 °C, the highest temperature ever reported for a solid-state transistor. These devices failed at 700 °C due to failure of the thin gate insulator and not the semiconductor. Process research has also yielded 6H-SiC thin films having a much lower defect density than β-SiC films.

This project will fabricate MOSFETs in both the depletion- and inversion-mode using the higher quality 6H-SiC thin film. It will investigate inversion-mode MOSFETs in the β-SiC for use in small signal amplification.

Potential Commercial Applications: Applications would be where operation of small signal amplifiers at high temperatures is required and where radiation resistance is desirable.

***

* 006
88-1-01.03-7070
Fast Optical Switch for Multi-Mode-Fiber-Optic-Based Control Systems
Geo-Centers, Inc.
7 Wells Avenue
Newton Centre, MA 02159
Bruce N. Nelson (617-964-7070)
LeRC – NAS3-25617

Optical switches will be an integral part of advanced aircraft control systems for directing optical signals to and from control system nodes and from arrays of sensors and actuators to electro-optic interfaces. Available optical switches for use with multi-mode-fiber optics are limited in switching speed to approximately 10 ms. This project is directed to the development of a fast optical switch which will be compatible with multi-mode-fiber optics and have an activation time of less than 1 ms. This switch will significantly increase the bandwidth capability of advanced aircraft control systems using multi-mode optical fibers.

The Phase I effort will determine the feasibility of the optical switching technique through laboratory experimentation. A two crystal, optical, single-pole-double-throw switch will be designed, fabricated, and evaluated during the Phase I effort.

Potential Commercial Applications: An application for the proposed optical switch could be use in the next generation of commercial aircraft control systems employing multi-mode-fiber-optic cable.

***

* 007
88-1-01.04-9030
H_2O_2 Three-Body Reaction Rates at High Temperatures
Physical Sciences Inc.
20 New England Business Center
Andover, MA 01810
William J. Marinelli (508-475-9030)
LeRC – NAS3-25566

Scramjet propulsion requires efficient fuel burning at low static pressures and high internal velocities. Calculations based on equilibrium chemistry are not valid under these conditions because many of the bi-molecular propagation and ter-molecular recombination reactions are slow. Modelling with finite-rate chemistry is hindered by poor knowledge of many of the three-body rate coefficients. This project uses innovative laser-induced fluorescence diagnostics in a unique facility to measure these rates at high temperatures. Radical species of interest will be produced cleanly by laser flash photolysis of parent compounds.

In Phase I, system capability will be demonstrated by measuring one of the three-body rates at a temperature of 1000 K and determining the sensitivity of the diagnostic method. Phase II of the project would measure several three-body rate coefficients as a function of temperature.

Potential Commercial Applications: The uses would be in the the development of single-stage-to-orbit vehicles.

***

008
88-1-01.05-0999
Conceptual Design of Ramfan Hypersonic Engine
CCS Associates
P.O. Box 563
Bethel Park, PA 15102
Calvin C. Silverstein (412-221-0999)
LeRC – NAS3-25616

The need exists for aircraft propulsion engines which can operate efficiently at flight speeds above Mach 3. An innovative hypersonic cruise engine, called the ramfan which incorporates both a ramjet and a fan, will be investigated. The project objectives are: to establish the current status of critical ramfan technologies, to determine the performance potential of the ramfan, and to assess the merits of the ramfan compared to a ramjet. These objectives will be achieved through the performance of three tasks. In Task 1, the critical ramfan technologies will be reviewed and their important features identified. In Task 2, parametric studies of ramfan design and performance characteristics will be conducted, and a preliminary conceptual design will be prepared. In Task 3, the feasibility of the ramfan concept will be assessed, and R&D requirements identified.

Potential Commercial Applications: The ramfan engine is potentially applicable to the propulsion of commercial transport aircraft at hypersonic speeds.

***

* 009
88-1-01.06-9282
New Computational Method for Aeroelastic Problems in Turbomachines
Continuum Dynamics, Inc.
P.O. Box 3073
Princeton, NJ 08543
Oddvar O. Bendiksen (609-734-9282)
LeRC – NAS3-25574

This project will test a novel and fundamentally different approach to calculations of aeroelastic and structural response of compressor and turbine engine rotors. The first phase of this effort will attempt to demonstrate the feasibility of coupling a finite-difference Euler code to a general purpose finite-element code using a mixed Eulerian-Lagrangian formulation. Part of this work consists of demonstrating the feasibility of carrying out time-accurate Euler calculations on a mixed-topology, periodic, deformable, cascade mesh using a finite-volume scheme with adaptive dissipation. This work includes establishing the necessary conformity relations at the fluid-structure interface and showing that a consistent mixed finite-difference, finite-element discretization can be achieved. Aeroelastic calculations for a prototype cascade problem will be initiated in Phase I; this code would be developed into a research tool in Phase II and a commercial code in Phase III.

Potential Commercial Applications: Results from this project could increase the capability of supercomputers for studies of fluid-structure interactions in all fields of engineering and, specifically, for the turbojet industry.

***

02 AERODYNAMICS AND ACOUSTICS

010
88-1-02.01-0333A
Automated Application of Navier-Stokes Solutions to Mechanical Design
Scientific Research Associates, Inc.
50 Nye Road, Box 1058
Glastonbury, CT 06033
Ralph Levy (203-659-0333)
MSFC – NAS8-38020

Ducts are currently designed through an iterative series of calculations and tests to obtain a duct meeting the design criteria. The proposed innovation would provide an easily utilized tool for design of a duct which is optimum for a specific application. Because many modern CFD codes currently require specialized expertise in aerodynamics and numerical methods, the design engineer who has the greatest need for these modern computational tools is often unable personally to utilize them. The innovation of the proposed effort is the combination of three elements: 1) existing robust computational techniques for computing two-dimensional and three-dimensional turbulent flow, 2) efficient, proven optimization techniques for multidimensional engineering problems, and 3) a workstation-based interface that would allow modern CFD codes to be accessible to many design engineers.

Potential Commercial Applications: A powerful computational tool usable by a broad range of design engineers could be the basis for a commercial venture by the firm.

***

* 011
88-1-02.01-0618
Techniques for Determining Goodness of Computational Meshes
Computational Mechanics Company, Inc.
3701 North Lamar, Suite 201
Austin, TX 78705
Jon M. Bass (512-467-0618)
MSFC – NAS8-38046

In computational fluid dynamics, finite-difference or finite-element grids are often generated using methods which can define fine meshes where required by detailed features of the flow or provide, through adaptive schemes, smooth orthogonal meshes with minimal distortion. Methods which predict the mesh goodness and the quality of the solution do not exist. This project addresses these needs through study of several pre-and post-processing techniques. In the

pre-processor, guidelines for an acceptable mesh will be provided via an a-posteriori estimation of the error potentially developed with a given mesh. An adaptive technique will then pre-process the mesh before expensive calculation is performed. Post-processing will use data from a computed solution and rigorous a-posteriori error estimates to judge the overall quality of the solution and, by using extraction and extrapolation routines, enhance the solutions of important flow problems. Initial studies will focus on steady two-dimensional Euler and Navier-Stokes equations.

Potential Commercial Applications: The new meshes and codes will provide a package of potentially great value to the aerospace industry.

***

012
88-1-02.01-4456
Goodness-of-Grid Measures
Program Development Corporation of Scarsdale, Inc.
300 Hamilton Ave., #409
White Plains, NY 10601
Peter R. Eiseman (914-761-1732)
ARC -- NAS2-12959

Numerical grid generation is a critical link in the chain of events leading to numerical solutions of partial differential equations of fluid mechanics. However, it is often (if not always) very difficult to ascertain how "good" a given grid is, particularly for three-dimensional configurations. This project is aimed at developing true, quantitative measures of a "good" grid along with improvements in adaptive grid strategies. The formulation of these measures will be based on the geometric characteristics of the flow field region, the variations in solution behavior, and the numerical algorithm under consideration. The method will offer an ability to select an "optimal" grid associated with the application being addressed and will provide diagnostic tools for grid systems.

Potential Commercial Applications: Engineers and scientists performing design analyses of complex systems may use the results of this project.

***

*** 013**
88-1-02.01-5682
Three-Dimensional Interactive Grid Generation
Visual Computing Inc.
883 North Shoreline Blvd., B-210
Mountain View, CA 94043
Jeffrey Q. Cordova (415-961-5682)
ARC -- NAS2-12960

This project concerns the development of a three-dimensional interactive grid package. The novel aspects include a universal algorithm for generating multiple-zone, structured and unstructured grids and the design of a visually oriented user interface. Visually integrated software produced from this effort would allow generation meshes for CFD projects up to 100 times faster than is now possible. This speed-up is comparable to that afforded by the use of next generation computer hardware.

Phase I will focus on developing a two-dimensional algorithm and exploring user interface issues associated with the display of three-dimensional manifolds. Phase II of the research will involve extending the two-dimensional algorithm to three-dimensions and integrating it with the user interface. Phase II will also include the development and use of new three-dimensional input devices.

Potential Commercial Applications: The results of this project could be used in CFD projects.

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*** 014**
88-1-02.02-0794
Microcomputer-Based Control of a Large Cryogenic Wind Tunnel
Vigyan Research Associates, Inc.
30 Research Drive
Hampton, VA 23666
Sundareswara Balakrishna (804-865-1400)
LARC -- NAS1-18810

The quality of data generated in a cryogenic tunnel such as the high-Reynolds-number, National Transonic Facility (NTF) depends on the stability of the flow states. The variation of the flow states is highly nonlinear and coupled to the tunnel control inputs. The 0.3-meter transonic cryogenic tunnel at Langley Research Center, which was the proof-of-concept demonstration for the NTF, has been operated under closed-loop control for eight years. Recently, full microcomputer control has demonstrated temperature stability within a range ± 0.15 K, Reynolds number within ± 0.03 million, and Mach number within ± 0.002. The control system applies a lumped-parameter method and standard, commercial, microcomputer hardware with flexible software written in a high-level, real-time language. The aim of this project is to apply this approach to the control system for the National Transonic Facility.

Potential Commercial Applications: A software-dominant approach is expected to provide an economical method to control large, cryogenic wind tunnels.

***

*** 015**
88-1-02.05-0056
Laser Velocimetry Processor for Hypersonic Flows
Physical Research, Inc.
25500 Hawthorne Boulevard - #2300
Torrance, CA 90505-6828
Dariush Modarress (213-378-0056)
ARC -- NAS2-12970

Accurate and detailed experimental data such as velocity distributions in complex flow fields at hypersonic speeds are required for validation of the analysis methods of computational fluid dynamics. While laser velocimetry (LV) has been successfully used in transonic and supersonic flows, its application to

hypersonic flows requires signal processors which are generally not available to date. The purpose of this project is to develop LV signal processors which can accept and process signals from small (0.2 to 0.3 micron) particles, analyze Doppler signals with frequencies of 100 MHz and higher, provide a wide dynamic range for the signal frequency and amplitude, and operate in flows of short duration.

During Phase I of the project, the system design will be completed for a LV processor capable of measuring three components of velocity for high-speed flows. The processor will be based on 32-bit architecture and will be developed and delivered to NASA during Phase II of the program.

Potential Commercial Applications: The product would be a laser velocimetry signal processor for research in three dimensional, hypersonic flows in short-duration wind tunnels.

***

016
88-1-02.05-1050A
Mechanisms of Energy Accommodation on Catalytic Surfaces
Chemical Dynamics Corporation
9560 Pennsylvania Avenue
Upper Marlboro, MD 20772
Bruce C. Garrett (301-599-1050)
ARC -- NAS2-12969

The goal of this project is the development of innovative theoretical approaches to gain an understanding of the microscopic mechanisms of gas-surface interactions, chemical energy accommodation, and surface catalytic reactions. The complex process of surface heating will be divided into its components and studied independently without the complications of competing processes. These studies comprise two parts: construction of realistic models of the interaction potentials as a function of internuclear distances and dynamical calculations of the motion of the atoms using the potential energy surfaces.

Phase I focusses on the rate of oxygen atom recombination reactions on a metal surface. The specific objectives are the development of realistic interaction potentials to describe reactive gas-surface interactions, the implementation of new dynamical methods to calculate the rate of gas-surface processes, the establishment of the reliability of the methods, and the identification of the features of the systems controlling the recombination rates.

Potential Commercial Applications: Understanding the mechanisms of surface heating could lead to the development of a computer software package and associated services for the aerospace industry.

***

017
88-1-02.05-1050B
Temperature-Dependent Energy Transfer Recombination on Surfaces
Chemical Dynamics Corporation
9560 Pennsylvania Avenue
Upper Marlboro, MD 20772
Pazhayannur K. Swaminathan (301-599-1050)
JSC -- NAS9-18088

Gas-surface interactions and recombination reactions, the key elementary processes responsible for surface heating in hypersonic flows, will be computationally explored. The innovative technology draws from the embedded atom and diatomic molecule methods, the quasi-classical trajectory method, molecular dynamics simulations, and stochastic heat-path modelling based on generalized Langevin equations.

Phase I will establish the basic technical feasibility of providing information for one chosen system on the partitioning of energy accommodation from various sources: translational, internal, and chemically released energy. This will be done while modelling the effect of the received energy within the condensed phase which is known to go beyond simple heating. Phase II will significantly enhance the body of knowledge on various selected materials and processes and lead to a distilled physical picture of the microscopic aspects of the surface heating problem that will be fundamentally based.

Potential Commercial Applications: Applications lie in many areas of chemical industry (catalysis), the aerospace industry (NASP, AOTV, hypersonic reentry, etc.), and in military technology.

***

*** 018**
88-1-02.05-8848
An Oblique-Detonation-Wave, Ram-Accelerator-Driven Hypersonic Test Facility
Advanced Projects Research International
5301 North Commerce Ave., Suite A
Moorpark, CA 93021
Joseph W. Humphrey (805-523-2585)
LaRC -- NAS1-18802

Current wind tunnels are inadequate for the high stagnation temperature and pressure conditions above Mach 8, and present ballistic technology cannot meet these requirements. Concepts, therefore, are needed to provide the capability of accelerating masses to six kilometers per second and above. This project will analyze and design a novel oblique-detonation-wave (ODW), ram-accelerator-driven propulsion concept for the acceleration of tube-launched projectiles to hypersonic velocities. Preliminary analysis indicates that an ODW ram accelerator can be designed to use conventional gaseous propellants for accelerating projectiles of practical size to velocities of six kilometers per second and above.

Potential Commercial Applications: The ram accelerator could be applied to research on re-entry vehicles and hypersonic transports, to launch planetary probes, and as a mass driver in Earth orbit.

***

019
88-1-02.05-9030A
Hypersonic Thermophysics Code
Physical Sciences Inc.
20 New England Business Center
Andover, MA 01810
Hartmut H. Legner (508-457-9030)
LaRC -- NAS1-18807

A hypersonic, aerothermodynamic flow-field computer program with emphasis on finite-rate and real-gas effects will be developed. At planetary entry and Earth return velocities, dissociation and recombination of atmospheric molecules and radiative phenomena have important effects on transport properties within the flow field, on heat transfer to the vehicle, and on aerodynamic coefficients. The innovation is a fully implicit, fully coupled, numerical integration method that provides reliable, stable, non-equilibrium solutions over a wide range of conditions from very slow reactions to situations arbitrarily close to equilibrium. A viscous shock layer formulation will be established for shock structures in rarefied applications with radiation and ablation coupling and surface chemistry effects. In Phase I, a non-equilibrium, boundary-layer code with kinetics and transport properties appropriate to Earth and Mars entry will be developed. In Phase II, this will be extended to a viscous shock layer code with the noted features.

Potential Commercial Applications: Possible applications include improved design of space vehicles for planetary, planetary-return, and Earth missions.

***

* 020
88-1-02.06-2008A
Model Development for Exhaust Plume Effects on Launch Stand Design
SECA, Inc.
3311 Bob Wallace Avenue - #203
Huntsville, AL 35805
S. D. Smith (205-534-2008)
MSFC -- NAS8-38028

Existing computational models for determining pressure and thermal effects induced by rocket plumes are too expensive for routine design of launch stands. For launch stands at NASA-KSC, the design process included use of five different computer codes that required a considerable amount of manual intervention for a single calculation. A unified, design model will be developed to treat arbitrary launch stand geometries with little or no user interaction from input of data to the output of impact pressure, heating rate, and temperature distributions. The program will combine an inviscid and viscous, two-dimensional, axisymetric flow code with a plume impingement model. This model will include effects of real-gas properties, chemical reactions, two-phases, and viscous-mixing. The output of this project will be a validated, efficient tool for predicting pressure and thermal effects on launch stands produced by liquid- and solid-rocket launch vehicles and missiles.

Potential Commercial Applications: Uses could be in the design of launch stands and engine test facilities for NASA, the Department of Defense, and commercial launch operations.

***

021
88-1-02.07-8581
Effects of Charge Separation in Hypersonic, Ionized Flows
Remtech, Inc.
3304 Westmill Drive
Huntsville, AL 35805
Peter A. Liver (205-536-8581)
MSFC -- NAS8-38032

The flow field around hypersonic vehicles is in chemical and thermal non-equilibrium due to significant dissociation and ionization in the region of shock waves and surfaces. Ambipolar diffusion of ions and electrons in these flow regions causes charge separation and induces electric fields that affect thermophysical properties and flow dynamics of multi-component gases. Since these effects are not included in current flow-field analyses, this project will attempt to establish the theoretical and computational procedure to include effects of charge separation into current computer programs and to assess the significance for future computational fluid dynamics models.

Phase I will define a set of species and fluid dynamics equations, a calculation procedure for thermophysical and transport properties for multi-component gas mixtures, and an efficient procedure to decouple species and thermophysical calculations from fluid dynamics solutions. The analysis will be implemented in the PARC Navier-Stokes codes in Phase II to assess the significance of the phenomenon of charge separation.

Potential Commercial Applications: The results of the may contribute to improvements in computational models for hypersonic vehicles.

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* 022
88-1-02.08-0618
Solution of the Navier-Stokes Equations on Unstructured Grids Based on Adaptive Methods and Operator Splitting
Computational Mechanics Company, Inc.
3701 North Lamar, Suite 201
Austin, TX 78705
Jon M. Bass (512-467-0618)
ARC -- NAS2-13000

Today, the majority of CFD calculations apply standard fixed-grid, finite-difference methods which cannot exploit current computing power nor deliver highly accurate simulations of fine-scale, complex flows. To solve complex flow problems that are not now treated satisfactorily, innovative computational procedures representing a significant departure from conventional, finite-difference flow solvers must be

developed. This project addresses two basic ideas for developing a new family of CFD codes: operator-splitting techniques that provide special, high-order schemes for the convection and diffusion steps in an unsteady, Navier-Stokes calculation and special h-p adaptive schemes on unstructured grids.

Phase I focusses on operator-splitting methods for Euler equations on unstructured grids giving particular attention to explicit methods that are second-order accurate in time. Reliable a-posteriori error estimators will provide a basis for h-p adaptivity.

Potential Commercial Applications: A new family of commercial CFD codes that are crucial for the design of aerospace systems and other external flows could result.

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* 023
88-1-02.08-9316B
Aerodynamic Control of NASP-Type Vehicles Through Vortex Manipulation
Eidetics International, Inc.
3415 Lomita Boulevard
Torrance, CA 90505
Gerald N. Malcolm (213-326-8228)
ARC -- NAS2-12989

It is well known that aircraft configurations with a high fineness ratio or highly swept delta wings, can experience significant low-speed handling problems while operating at angles-of-attack representative of take-off, approach, and landing. This project aims to show that alternative methods of aerodynamic control, vortex control concepts, can either augment or, to some degree, replace conventional control methods. New concepts for low-speed control could enhance optimization of the airframe design to meet hypersonic requirements.

Phase I will consist of water tunnel flow visualization experiments with proposed National Aerospace Plane (NASP) configurations or an acceptable "generic" NASP configuration to identify the most promising methods of controlling the critical vortices including local surface blowing and minor geometric configuration changes that could be produced by the controlled movement of small non-conventional control surfaces. Success in the Phase I feasibility studies could lead to further development through wind tunnel testing in Phase II.

Potential Commercial Applications: The results could apply to the design of high-performance military and commercial aircraft.

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024
88-1-02.09-7121
Joined-Wing, Tilt-Rotor Aircraft Study
ACA Industries, Inc.
28603 Trailriders Drive
Rancho Palos Verdes, CA 90274
Julian Wolkovitch (213-539-7121)
ARC -- NAS2-12988

The joined-wing airplane employs two sets of wings rigidly connected together to form a triangulated, self-bracing structure. Structural analyses and wind-tunnel tests have shown that, compared to cantilever-wing aircraft, joined-wing aircraft are lighter and stiffer and have lower induced drag. The joined wing also permits thinner airfoils to be used, thus increasing the Mach Number for drag divergence and the maximum speed. Applied to tilt-rotor aircraft, in addition to the advantages cited, the joined wing may reduce adverse downwash effects in hover. This project will delineate joined-wing, tilt-rotor configurations that give maximum increases in performance. It will compare the performance and aeroelastic characteristics of joined-wing versus cantilever configurations and outline detailed analyses and tests which will provide a data base for design of joined-wing, tilt-rotor aircraft.

Potential Commercial Applications: This project may lead to performance improvements for military and civil tilt-rotor aircraft which will combine the hover capability of helicopters with the cruise speed of fixed-wing aircraft.

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* 025
88-1-02.09-9090
A Novel Potential- and Viscous-Flow Coupling Technique for Computing Helicopter Flow Fields
Analytical Methods, Inc.
2133 152nd Avenue, N.E.
Redmond, WA 98052
J. Michael Summa (206-643-9090)
ARC -- NAS2-12962

Because of the complexity of the helicopter flow field, a zonal method of analysis of computational aerodynamics is required. In this project, a new procedure for coupling potential-and viscous-flow calculation schemes by an overlapping, velocity-coupling technique is to be developed. The unique feature is that potential-flow, surface-singularity strengths are obtained directly from the Navier-Stokes solution at a smoother inner fluid boundary. The closed-loop iteration method proceeds until the velocity field is converged. This coupling should provide the means of more accurate viscous computations of the near-body and rotor flow fields with resultant improved analysis of such important performance parameters as helicopter fuselage drag and rotor air loads.

Potential Commercial Applications: This work could apply to designing helicopters with better lift and drag performance, reduced noise, and reduced vibrations.

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026
88-1-02.11-0161
Very High Temperature Fiber Sensors
LaserGenics Corporation

Box 611330
San Jose, CA 95161-1330
Richard G. Schlecht (408-433-0161)
LaRC -- NAS1-18815

Advanced wind tunnel instrumentation will require highly sensitive devices for measuring temperatures in the range of 1800 °C to 3000 °C. In order to make accurate temperature measurements in this extreme environment, new concepts in sensor design will have to be employed, because available thermometry devices will not perform reliably in this environment. Fiber optic sensors offer a possible solution but available fibers of glass or silica cannot withstand this temperature range. This project addresses the use of single-crystal, fiber optics which can be used at these extremely high temperatures. A variety of high temperature refractory, single-crystal fibers will be grown with different dopants in the tip of the fiber that will serve as a blackbody radiation source. The emission from this source will then be detected and analyzed to determine the tip temperature.

Potential Commercial Applications: A number of uses may occur in process control in the steel, chemical, semiconductor industries, in fossil fuel and nuclear power generation plants, and in research in plasma physics, fusion, MHD, combustion, and chemistry.

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* **027**
88-1-02.11-1322
Non-Intrusive, Fast-Response Oxygen Monitoring System for High-Temperature Flows
Southwest Sciences, Inc.
1570 Pacheco Street - Suite E-11
Santa Fe, NM 87501
Alan C. Stanton (505-984-1322)
LaRC -- NAS1-18829

This project addresses the need for fast-response measurement of molecular oxygen concentrations in high-temperature flows for research on hypersonic air-breathing engines as well as in combustion research and control. The innovation uses inexpensive, room-temperature, laser diodes operating at near-infrared wavelengths and combined with high-frequency, FM detection techniques. This approach should yield a non-intrusive oxygen monitor with high sensitivity, wide dynamic range, the capability for an extremely fast response. In comparison with other optically based methods, the proposed approach uses exceptionally reliable and inexpensive laser sources which can readily be combined with fiber optics for multi-point monitoring. The feasibility of the technique will be evaluated in Phase I by measurements in a room-temperature absorption cell and in the post-flame gases of a methane-oxygen flame.

Potential Commercial Applications: Applications may develop in monitoring or controlling combustion processes, industrial chemical plants, and toxic gas emissions.

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028
88-1-02.12-3077
Acousto-Fluidic Noise Generators for Aircraft Component Structure Testing
Defense Research Technologies, Inc.
354 Hungerford Drive
Rockville, MD 20850
Allen B. Holmes (301-762-3077)
LaRC -- NAS1-18820

Current noise generators now in use by the NASA-LaRC Acoustic Research Facility are electro-mechanical devices which operate at low temperatures (70 °F) and produce noise levels up to 168 db. Since testing of advanced aircraft structures and materials to noise levels up to 190 db at elevated temperatures is required, this project is examining the technical feasibility of using fluidic oscillators to generate both narrow-band (constant frequency) and broad-band noise using high temperature (1800 °F) propellant gas flows to generate noise in the 190 db power range. In the present state-of-the-art, however, fluidic sound generators are miniature devices which have been operated at low pressures and flow rates to produce sound pressure levels of approximately 130 db.

The Phase I effort will survey fluidic devices for use as hot-gas noise generators in the Acoustic Research Facility. The results will be used to assess the feasibility of scaling up oscillator designs to generate the desired noise power levels.

Potential Commercial Applications: The applications could be in testing advanced structures and materials for supersonic aircraft.

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03 AIRCRAFT SYSTEMS, SUBSYSTEMS, AND OPERATIONS

* **029**
88-1-03.01-0533
Aircraft Icing Performance Measurement System
Innovative Dynamics
Cornell University Research Park
244 Langmuir Laboratory
Ithaca, NY 14850-1296
Gail A. Hickman (607-257-0534)
ARC -- NAS3-25618

This project deals with a unique solid-state, low-cost, rugged ice detection system to reduce the hazards of aircraft icing. This system will sense an impending wing-stall condition of an aircraft by directly measuring the intensity of turbulent airflow induced by ice accretion. The key system components are piezoelectric transducers for sensing boundary-layer pressure fluctuations and a microcomputer for digital signal processing. The incorporation of a wireless data link will enable simple implementation of a non-intrusive system easily retro-fitted on aerodynamic surfaces, engine inlets, and fuel tanks. Flight tests will be performed on a Grumman AA-5 aircraft with simulated leading edge ice to demonstrate system

feasibility. If successful, this work will lead to the development of an operational ice detection system during the Phase II.

Potential Commercial Applications: The product could be a low-cost sensor for de-icing systems of current and future aircraft fleets, both civilian and military.

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* 030
88-1-03.01-9457
Unstructured Triangular Mesh/Navier-Stokes Method for Aerodynamics of Aircraft with Ice Accretion
Nielsen Engineering & Research, Inc.
510 Clyde Avenue
Mountain View, CA 94043-2287
Steven C. Caruso (415-968-9457)
LeRC -- NAS3-25601

Ice accretion on fixed-wing aircraft and rotorcraft can cause aerodynamic penalties such as increased drag, decreased lift, reduced stall angle, increased stall speed and increased engine horsepower requirements. There is currently a need for effective design methods for ice protection systems to be used for qualification and certification of aircraft and for research into icing phenomena. Current icing analyses consist of three basic components: water-droplet trajectory calculations, determination of ice deposition and growth, and a flow-field analysis which is used both for the evaluation of the droplet trajectories and of the aerodynamic penalties. This project concerns the development of an innovative, flow-field prediction method in which the Navier-Stokes equations are solved on an unstructured, triangular (tetrahedral in three dimensions) mesh system. This method is intended to be used in an overall icing simulation scheme.

Potential Commercial Applications: Improved understanding of aircraft icing could decrease development time and costs of ice protection systems and aid in the qualification and certification of aircraft.

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* 031
88-1-03.02-9282
A Liquid Water Content Meter
Continuum Dynamics, Inc.
Box 3073
Princeton, NJ 08543
Alan J. Bilanin (609-734-9282)
LaRC -- NAS1-18819

There is growing evidence that, under very heavy rainfall rates, airfoils will suffer aerodynamic performance penalties. Rainfall rates and liquid water content (LWC) are directly correlated. NASA testing planned for later this year will attempt to quantify these penalties as a function of LWC to determine at what level LWC-induced performance degradation presents a serious hazard. It is currently not known for what period of time or at what altitude high LWCs in the atmosphere will be encountered, since instrumentation to make these measurements has not yet been developed. This project investigates the feasibility of developing an aircraft-mounted LWC probe which will ascertain the LWC from measurements of water film thickness and determine the probability of a hazard caused by heavy rainfall rates.

Potential Commercial Applications: The LWC probe might become a standard warning indicator in aircraft cockpits if research shows that high rainfall rates are hazardous to aircraft operations.

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* 032
88-1-03.03-0371
A Stochastic, Optimal, Feedforward and Feedback Control Methodology for Super-Agility
Information & Control Systems, Inc.
28 Research Drive
Hampton, VA 23666
Nesim Halyo (804-865-0371)
LaRC -- NAS1-18812

A new combined feedforward and feedback control design methodology will be investigated for multi-input, multi-output dynamical systems such as the modern tactical aircraft. In particular, the design of controllers for super-agility is addressed by an innovative concept of determining the unconstrained stochastic, optimal, feed-forward control law to achieve high maneuverability within a greatly expanded flight envelope. The approach is applicable to high-performance aircraft with static instability, numerous control effectors, and thrust vectoring with requirements for integration of aerodynamic, propulsive, and flexible modes. The structure of the optimal feedforward and feedback controllers and algorithms to compute the required control parameters will be demonstrated by simulation of a typical design problem.

Potential Commercial Applications: Applications could occur in the design of control systems for military and commercial aircraft including supersonic transports and aerospace planes.

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033
88-1-03.03-9316A
Agility Management System for High-Performance Aircraft
Eidetics International, Inc.
3415 Lomita Boulevard
Torrance, CA 90505
John Hodgkinson (213-326-8228)
LaRC -- NAS1-18805

An innovative approach is proposed which would add adaptive features to current angle-of-attack and load-factor-limiter concepts to aid pilots in energy and agility management during operation of high-performance aircraft. The agility management system would be scheduled with aircraft motion quantities to give

the pilot improved control and cuing of turn rate and excess specific power. It would be applicable to any high-performance aircraft, current or future, which has a flight control system with sufficient sensed quantities available.

Potential Commercial Applications: This innovation would be of interest to suppliers of aircraft, flight control systems, and propulsion systems.

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034
88-1-03.04-7300
Multilevel Motion Processing for Autonomous Helicopters
Advanced Decision Systems
1500 Plymouth Street
Mountain View, CA 94043-1230
Daryl T. Lawton (415-960-7300)
ARC -- NAS2-12967

A fundamental problem with automating nap-of-the-Earth helicopter flight is the extraction and representation of information about the rapidly changing relationship between the helicopter and its environment. In this project, analysis of motion involves several explicit levels of processing and representation for determining image motion and building environmental inferences. The different levels, which constrain and direct each other significantly, range from very local and simple descriptions of temporal changes in image intensity to qualitative and potentially robust descriptions of the relative depths of coherent environmental surfaces and occlusion boundaries. This range of representation and constraints can effectively address problems associated with the typically brittle environmental inferences associated with motion processing. The results will supply NASA with an extensive set of algorithms that can be tested and combined. This is particularly important since the exact use and nature of motion processing for helicopter systems will vary based upon several evolving factors.

Potential Commercial Applications: Analysis of dynamic visual information could be applied to industrial inspection, surveillance, change detection, and robot guidance and navigation.

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*** 035**
88-1-03.05-0533
Experimental Investigation on the Detection of Transitioning Flow-Fields
Innovative Dynamics
Cornell University Research Park
244 Langmuir Laboratory
Ithaca, NY 14850-1296
Joseph J. Gerardi (607-257-0533)
ARC -- NAS2-12890

The objective of this project is to develop a unique, aerodynamic flow sensor that will passively sense laminar, transitional, and turbulent boundary-layer flow. This innovation incorporates a thin, solid-state polymer film that senses both normal and shear boundary layer forces. Preliminary tests on the wing of a Grumman AA-5 test plane yielded data that resembles the classical Tollmien-Schlichting waves that occur in the boundary layer transition region. This technology will be extended to produce the advanced, passive, boundary-layer transition detection system that can operate non-intrusively and reliably throughout the subsonic flight envelope. Prototype hardware will consist of a piezoelectric sensor array strip with an integrated data telemetry link. A data processing and display unit will receive and process the data and display the stream-wise boundary layer profile in a real-time or averaging mode. During Phase I, the prototype will be installed on the NASA F-104/FTF for flight test and calibration.

Potential Commercial Applications: The boundary-layer transition detection system could be used as a feedback sensor for an adaptive wing and for flow measurements on wind tunnel models and flight test aircraft.

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*** 036**
88-1-03.05-8161A
Applications of Transputers in Aircraft Flight Research
Sparta, Inc.
23041 Avenida de la Carlota - Suite 400
Laguna Hills, CA 92653
Marie D. Hewett (714-768-8161)
ARC -- NAS2-12887

The innovative concept proposed herein involves a low-cost, high-performance, expandable, highly reliable, airborne, auxiliary digital computer for conducting flight research in high performance aircraft. This flight research computer would perform on-board computations such as display generation, trajectory optimization, parameter identification, and advanced control algorithms. It will be based on transputer technology which is adaptable in size, shape, weight, performance (computer throughput), and tasks (applications software) and can accommodate a wide range of flight research applications. The algorithms will be research programs written in "C", Ada, and/or FORTRAN.

This innovation parallels a NASA in-house development of a transputer application to data acquisition, pre-processing and filtering, compression, and telemetry. The flight research computer, however, addresses on-board digital computation requirements directly related to flight research and must interface with a larger variety of data sources than the instrumentation computer.

Potential Commercial Applications: The flight research computer has military, FAA, NASA, and commercial applications and could be used by academic institutions which conduct flight research.

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037
88-1-03.06-0333
Fluorescence Spectroscopy and Thermometry for Hypersonic Flight Research
Scientific Research Associates, Inc.
50 Nye Road - Box 1058
Glastonbury, CT 06033
Brian E. Thompson (203-659-0333)
LaRC -- NAS1-18804

This project will investigate two innovative instruments for flight research at Mach numbers between 4 and 15. One is a steady-state spectro-fluorimeter, and the other, a laser-induced-fluorescence thermometer for non-intrusive measurements in the middle atmosphere. The spectro-fluorimeter would gather information about the fluorescence characteristics of air which would then be applied to the design of a time-resolved, laser-induced-fluorescence thermometer to obtain distributions of mean and fluctuating temperatures in the boundary layer of hypersonic flight research vehicles. The innovative time-resolved measurement can produce useful results at low fluorescence intensities and provide quenching corrections needed for practical application of fluorescence to flight research.

Phase I would assess both instruments by evaluating critical aspects of resolution of fluorescence signals and fluorescence characteristics of the real gases at flight conditions. Engineering design, research, and development in Phase II would provide prototypes of the spectral fluorimeter and fluorescence thermometer for flight testing during Phase III.

Potential Commercial Applications: The could be in flight research on future Shuttle generations, hypersonic reentry vehicles, planetary probes, and hypersonic transport aircraft.

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038
88-1-03.06-5287
Sensors for Flight Research
Research Innovation Implementation, Inc.
2201 Donley
Austin, TX 78758
Jon M. Schroeder (512-832-5287)
ARC -- NAS2-12886

Polymeric, printed-circuit board technology allows resistors, capacitors, inductors, and even diodes to be formed as micro-scale components while interconnecting integrated circuits. This technology has been advanced by using computer-aided manufacture for polymer-additive and subtraction methods for multi-layer chip interconnections. By using this method, micro-scale devices, such as accelerometers, sensors, and motors, can be fabricated. This project involves the design, development, and batch manufacturing of a variety of active and passive devices which can be used as sensors, actuators, and transducers for flight research. By using polymer materials and integrated circuit techniques at the board level, a nearly finished, integrated-board system results. A combination of methods will be used to produce custom sensors as well as production parts. The process is extremely repeatable and will produce a wide variety of lightweight electro-mechanical sensors and transducers with integrated electronics and photo-optical links.

Potential Commercial Applications: The commercial marketplace could benefit from a light-weight, fast-response, reliable, and technically improved sensor with an electronic interface that can be manufactured automatically at low cost.

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* 039
88-1-03.06-5649
Interferometric Imaging and Frequency Estimation of Surface Vibration Patterns
Daedalus Enterprises, Inc.
Box 1869
Ann Arbor, MI 48106
Keith A. More (313-769-5649)
ARC -- NAS2-12889

The project investigates the feasibility for developing an instrument for measuring surface vibration patterns using an innovative combination of laser illumination and interferometric imaging coupled to a novel digital signal processor. The effort will investigate the feasibility of optical heterodyne detection in terms of beam alignment, stability, and noise to determine whether a heterodyne receiver can be built. In addition, a significant part of the effort will be devoted to designing a digital processor with sufficient speed to sample the high frequency data and to display large surface areas as a mosaic of pixels . Successful completion of this project will result in the preliminary design and performance prediction for a new instrument to be used for the accurate measurement of vibration patterns of structural surfaces for aeronautical and aerospace vehicles.

Potential Commercial Applications: Applications are expected in the design of commercial aircraft and other vehicles in which vibration of structural surfaces is a critical design parameter.

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040
88-1-03.07-1500
Numerical Optimization of Single-Stage-to-Orbit Configuration with Inequality Constraints
Integrated Systems, Inc.
2500 Mission College Boulevard
Santa Clara, CA 95054
M. Michael Briggs (408-980-1500)
LaRC -- NAS2-18801

The objective of this project is to perform numerical optimization of hypersonic body configurations applicable to single-stage-to-orbit aerospace plane configurations. A new, interior quadratic programming procedure with rapid convergence, recently developed by the firm, allows complex problems to be solved

numerically by converting the optimization process into a problem in nonlinear programming. The new algorithm is embedded within an augmented Lagrangian approach for solving general, nonlinear programming problems. This project will develop a general control-oriented method for specifying the body optimization algorithm. The body geometry subroutine will provide definition of the external shapes of hypersonic vehicles for the computational fluid dynamics code that will be used to evaluate the performance index. Performance indices (cost functions) will be constructed that reflect the principal measures of merit, and inequality constraints will be applied to represent heating rate and component packaging constraints at various levels. Optimization runs will be accomplished to define the optimum body shapes for various flight conditions.

Potential Commercial Applications: The resulting software package can be offered as a commercial product that simplifies the application of modern numerical methods to configuration optimization.

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* **041**
88-1-03.09-9915
Intelligent Hypertext Systems for Aerospace Knowledge Representation
Engineering Research and Consulting, Inc.
Box 417
Tullahoma, TN 37388
Z. George Shi (615-455-9915)
ARC -- NAS2-12965

Knowledge about aerospace ground testing often consists of diffuse and dispersed sets of information that is hard to collect and more difficult to understand and master. This project is designed to utilize artificial intelligence technology for assisting users to locate and understand technical information in manuals for planning and conducting tests in wind tunnels and for increasing the efficiency of training personnel in testing procedures. A computerized manual will be created in the form of Hypertext and an advisory system which stores experts' knowledge and experience. The combined Hypertext manual and advisory system is termed an Intelligent Hypertext (IH) System.

Phase I of the project will implement a prototype IH-system for conducting transonic wind tunnel testing. Phase II of the project will extend the concepts to encompass aerodynamic testing knowledge in expanded domains including supersonic, hypersonic, and low-speed V/STOL tunnels.

Potential Commercial Applications: A general system for capturing and manipulating aerospace engineering knowledge could become a commercial venture.

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042
88-1-03.10-8161
Expert Systems for Flight Control Systems Verification
Sparta, Inc.
23041 Avenida de la Carlota - Suite 400
Laguna Hills, CA 92653-1507
Pio de Feo (714-768-8161)
ARC -- NAS2-12888

This innovation applies a knowledge-based system for automatic verification and optimization of flight control systems (FCS). The major elements include: real-time simulation of the aircraft's dynamics, the flight-control computers (FCC), and the test and optimization manager (TOM). The TOM, the key component, accepts high level test objectives from the test engineer, translates them into sets of initial conditions for the aircraft simulation and the FCC, controls execution, collects test outputs, and performs the fine tuning of the control laws all automatically. It will be implemented using available artificial intelligence software and hosted in a workstation. The benefits of this approach are: increased confidence in the verification process through the use of prior experience that may not exist within small teams of test engineers, effective utilization of equipment which is typically in high demand, and rapid flight test turnaround.

Potential Commercial Applications: The results of this project could be applied by military and commercial airframe and avionic companies and for other real-time, critical applications such as automated control of nuclear reactors.

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043
88-1-03.11-2526
Voice I/O for Flight Management Systems
Emerson & Stern Associates, Inc.
10150 Sorrento Valley Road - Suite 210
San Diego, CA 92121
S. E. Hutchins (619-457-2526)
ARC -- NAS2-12972

This effort investigates the feasibility of a voice I/O (input/output) system for commercial aircraft to facilitate interaction with a sophisticated flight management system. The I/O system incorporates a speech recognizer with near natural language capabilities and a speech synthesizer that is easily understood and clearly identifiable as machine speech. Development of these innovations relies on the firm's existing voice I/O capabilities for real-time speech processing.

Work in Phase I includes collecting and analyzing voice interactions in the cockpit, defining a command language for the sample application of database inquiry and response, determining human performance on this command language at various noise levels, analyzing supra-segmental data, developing appropriate "machine speech" with proprietary tools, adapting the firm's speech algorithms to cockpit noise conditions, comparing recognizer performance to human performance, and, finally, comparing the intelligibility of human speech to "machine speech."

Potential Commercial Applications: Voice I/O could be useful in commercial airliners, single-pilot craft,

helicopters, and tactical aircraft. Other applications include communications and dispatching centers, factory automation, and air traffic control.

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044
88-1-03.11-3474
EEG-Based Metric for Flight Deck Workload Assessment
Charles River Analytics Inc.
55 Wheeler Street
Cambridge, MA 02138
Greg L. Zacharias (617-491-3474)
LaRC -- NAS1-18806

The Phase I effort will evaluate feasibility of an electroencephalographic (EEG), real-time metric for use in flight deck workload assessment and future self-adaptive automated cockpits. The approach will center on the use of the steady-state, visually evoked response (ssVER) and involve active probing under a range of perceptual and cognitive loading conditions. On-line measurements will be processed to yield workload-sensitive ssVER model parameters which will be incorporated in a VER-based metric, for real-time workload and mental state assessment. This metric will be validated via five tasks: the current ssVER measurement system will be realized on a personal computer, a simulated flight deck management task will be implemented, a validation experiment will be conducted to demonstrate the proposed methodology, candidate metrics will be specified and evaluated based on the experimental results, and the feasibility of prototype development will be assessed and the Phase II program outlined.

Potential Commercial Applications: Uses could occur in supervisory task and process management situations, such as in rail traffic management, chemical plants, and power generation.

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04 MATERIALS AND STRUCTURES

045
88-1-04.01-1049
Software System for Predicting Engineering Properties of Polymer Matrix Resins
Advanced Materials Design, Inc.
1291 East Cumberland Avenue
West Lafayette, IN 47906
Alok K. Kulshreshtha (317-497-1049)
LeRC -- NAS3-25567

An integrated software package will be developed to predict the engineering properties of polymers used as matrix resins in aerospace composites. The software is built upon a nonlinear visco-elastic constitutive equation that acknowledges the fundamental deformation processes. The constitutive equation predicts the complete stress-strain behavior including yield for glassy polymers in arbitrary, time-dependent, three-dimensional deformation fields. The objective of this project will be to develop an efficient, robust, and user friendly code that can assist polymer scientists and engineers in developing new resins for advanced aerospace applications.

Potential Commercial Applications: The software will enable order of magnitude reduction in the time and expense required to develop and/or evaluate new polymers for engineering applications.

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046
88-1-04.01-2681
Improved CVD Silicon Carbide Fibers
Advanced Technology Materials, Inc.
520-B Danbury Road
New Milford, CT 06776
Ward C. Stevens (203-355-2681)
LeRC -- NAS3-25569

Engines of high thrust-to-weight ratio and hypersonic vehicles require high-temperature structural materials which depend on the availability of suitable fiber reinforcements. Commercially available silicon carbide fibers formed by chemical vapor deposition (CVD) suffer from poor creep resistance, a result of free silicon found at the grain boundaries. This problem, a direct result of the fiber fabrication process, limits their use to temperatures less than 1000 °C. A unique source reagent for CVD has been developed for the electronics community which enables the reproducible growth of stoichiometric, single-crystal, silicon carbide for high power electronic devices. This reagent should enable the fabrication of a silicon-free, silicon carbide fiber which should be creep resistant to 1550 °C.

Phase I will determine the physical properties and the high-temperature mechanical properties of monofilament silicon carbide made by CVD using this innovative, "molecular-source" reagent. Phase II will more fully develop the properties of the fiber and develop a manufacturing process for its production.

Potential Commercial Applications: The applications would be in hot sections of high-temperature turbofan and turbojet engines and structures on hypersonic vehicles.

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047
88-1-04.02-3779
Continuous, On-Board, Non-Destructive Monitoring of Degradation of Fiber Composites
Technology Integration and Development Group, Inc.
One Progress Road
Billerica, MA 01821
Gino A Pinto (508-667-3779)
LeRC -- NAS3-25575

Composite materials are being introduced into a variety of critical aerospace applications. Damage develops in these composites due to fatigue and environmental effects. Monitoring the condition of these composites is, therefore, needed in order to

assess the composite's structural reliability. This project addresses the feasibility of an in-service, microsensor-based, health monitoring system in order to determine degradation in the composite's stiffness and strength properties and predict the composite's useful remaining service life. In situ analysis techniques will be used to determine degradation in composite structural stiffness properties. Strength degradation will be determined through a recently developed correlation between degradation of stiffness and strength. Microsensors and microactuators will be considered as low-cost, low-weight candidates for an in-service system. Implementation schemes devised for the proper implementation of the sensors into the composites will also be considered in Phase I.

Potential Commercial Applications: Applications could occur in all industries which manufacture or utilize composite structures.

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* **048**
88-1-04.03-3200A
Prepregging for High-Temperature Thermoplastics
Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02254
Richard W. Lusignea (617-890-3200)
LaRC -- NAS01-18817

The development of high-quality, producible, high-temperature, thermoplastic carbon composites is being sought by the aerospace industry. New thermoplastic composites will meet the required high specific performance of all classes of advanced aircraft, will reduce fabrication and life-cycle cost, and will greatly simplify maintainability. One of the major obstacles to high-temperature, thermoplastic carbon composites has been the inability to produce continuously a uniform, void-free prepreg, the first step in composite fabrication. This project will evaluate a novel prepregging method using high-shear strain-rates to reduce melt viscosity of the polymer and provide very complete wetting and distribution of the fibers. The method will provide improvements over current resin composites, including elimination of voids, uniform fiber distribution, and high volume percent (over 60 percent) of fiber. Prepregged material will be fabricated into composite test samples for mechanical testing and microscopic analysis.

Potential Commercial Applications: The process could be applied in producing primary and secondary structures of commercial aerospace vehicles, high-temperature electronics, and light-weight, impact-resistant structures for automobiles.

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049
88-1-04.03-5224
Thermally Stable, Low Dielectric Films for Aerospace Applications
Maxdem Inc.
267 South Fair Oaks Avenue
Pasadena, CA 91105
Neil H Hendricks (818-793-5224)
LaRC -- NAS1-18832

The goal of this project is to prepare new thermoplastic polyquinolines with excellent combinations of thermo-oxidative stability and desirable electrical properties. Samples of the new polymers will be cast into films and provided to the Polymeric Materials Division at NASA-LaRC for evaluation of mechanical and electrical properties. The aromatic polyquinolines are characterized by very high glass transition temperatures (T_g) and good retention of properties below T_g. In addition, the dielectric properties of one derivative are reported to be excellent. Tough, transparent polyquinoline films may be cast from solution and may require no post-cure stages. This suggests that polyquinolines may be useful as films and coatings in aerospace applications. Tailoring of the polyquinoline structure to optimize performance characteristics will be based on structure-property relationships observed in polyimide chemistry.

Potential Commercial Applications: Polyquinolines may replace existing polymers that are currently used for wire coatings, capacitors, etc. at the extremes of required use temperatures.

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050
88-1-04.03-7356R
Thermal Control Coatings for Composite Structures
DSET Laboratories, Inc.
Box 1850 Black Canyon Stage I
Phoenix, AZ 85029
John E. Bruzuskiewicz (602-465-7356)
LaRC -- NAS1-18825

This project addresses the development of a thermal-control coating to maintain advanced composite materials within a specified temperature range. The principal effort will be devoted to formulating a manufacturable, atomic-oxygen-resistant spacecraft coating having both the requisite $\alpha_s/$ ratio (= 0.8) and stability in the ultraviolet environment in space. Emphasis will be given to tailoring $\alpha_s/$ employing metal and metal-flake pigments with and without additional pigments in low-outgassing binder systems.

Potential Commercial Applications: Commercial applications could occur in the aerospace industry for years to come.

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051
88-1-04.04-7648
Synthesis of High-Purity Refractory Beryllides
MSNW, Inc.
P.O. Box 865
San Marcos, CA 92069
George H. Reynolds (619-744-7648)
LaRC -- NAS1-18821

This project will examine alternative methods for synthesis of high-purity refractory beryllides in either

powder, foil, or bulk form. Analytical efforts and process modeling will focus on those methods which are capable of producing two-component, intermetallic compounds of the required stoichiometry while simultaneously reducing the contamination levels or increasing the purity of product materials relative to the starting materials used. The Phase I effort will result in the process design of one or more systems for pilot-scale production of high-purity refractory beryllide powders, foils, or bulk materials in Phase II.

Potential Commercial Applications: The refractory beryllides could be useful in flight-weight structures for missile components, turbine engine compressor blading, and truss elements for space structures.

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052
88-1-04.06-0236
Hydrogen Collectors for Space Flight Applications
Ultramet
12173 Montague Street
Pacoima, CA 91331
Richard B. Kaplan (818-899-0236)
GSFC -- NAS5-30485

In order to avoid over-board venting of the hydrogen gas used in various ways in space, a high-performance, light-weight, and simple system is required to collect and store hydrogen. This project will investigate the feasibility of infiltrating a carbon foam with a hydrogen-absorbing, intermetallic compound by a variation of the chemical vapor deposition process. The resultant composite foam structure will meet the requirements of being lightweight, having a high surface area with which to capture hydrogen, and being simple in design and use.

Potential Commercial Applications: The material developed in this project could be used for collecting and retaining hydrogen, deuterium, and tritium for nuclear energy applications or for upper atmosphere testing.

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053
88-1-04.07-2260
Erosion- and Oxidation-Resistant Protective Coating for Polyimide Sheeting
Midwest Research Microscopy, Inc.
5510 West Florist Avenue
Milwaukee, WI 53218
Norman A. Draeger (414-527-2260)
JSC -- NAS9-18090

Polymide materials, notably Kapton, find use in the outer coverings of space vehicles for purposes such as thermal insulation. While exposed to the energetic atomic oxygen present in a low-Earth orbital environment, the Kapton undergoes a degradation process. It has already been found that a coating of silicon oxide or aluminum oxide over the Kapton greatly extends its service life during this exposure to oxygen. However, the oxide coatings are brittle and subject to cracking. The purpose of this project is to develop a coating with the desirable protective properties of the earlier films but with much more resistance to cracking. Secondarily, it would also be desirable for this new film to be UV-opaque, since UV radiation also causes a chemical degradation of Kapton.

Potential Commercial Applications: The coating may be used to protect Kapton surfaces used in microelectronic applications exposed to an oxidizing atmosphere. The production-scale coating technique could have a number of commercial uses.

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054
88-1-04.07-3812
Perfluoropolyether Copolymers Containing Tetrafluoroethylene Oxide
Exfluor Research Corporation
Box 7807
Austin, TX 78713-7807
Timothy J. Juhlke (512-454-3812)
LeRC -- NAS3-25564

The goal of this project is to prepare a series of substituted methylene oxides containing perfluoroether compounds to model high-molecular-weight perfluoropolyethers which will have similar structural features. The model compounds will be prepared using newly developed direct fluorination techniques which convert hydrocarbons of appropriate structure directly to perfluorocarbons. The perfluoroethers produced will be used in surface studies as well as in aggressive environments where their comparative stabilities will be measured. Upon identifying structures with exceptional properties, perfluoropolyether fluids and elastomers based on those structures will be developed. All of the polymers modeled by the proposed structures are accessible using our technology, and each is expected to give fluid with low pour points and high oxidative stabilities as well as oxidatively stable elastomers with very low glass-transition temperatures (-60 to -90 °C).

Potential Commercial Applications: (None specifically identified by the firm.)

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055
88-1-04.07-6410
Titanium Carbide Used to Protect Carbon Composites
Tracer Technologies, Inc.
20 Assemble Square Drive
Somerville, MA 02145
Fraser Walsh (617-776-6410)
JSC -- NAS9-18109

The objective of this project is to demonstrate the technical feasibility of increasing the thermal tolerance and metal wettability of carbon composite materials through the application of a titanium-carbide ceramic to their surface. The application process will be laser-based and will result in the covalent bonding of the

ceramic to the carbon substrate surface. The ceramic-layered carbon composite will be protected from thermal damage by the ceramic layer and from the stresses of thermal cycling by the covalent bond between the layer and the carbon surfaces. The ceramic layer will increase the wettability of the carbon substrate to molten metals and thus enhance its use in the manufacture of graphite-reinforced, metal-matrix composites. The titanium-carbide-protected carbon composites will be formed and stressed at high temperature to demonstrate thermal tolerance and oxidation resistance. Metal wettability will also be demonstrated. Ceramic layer physical and chemical characteristics will be determined using scanning electron microscope and Auger profile analysis.

Potential Commercial Applications: The ceramic-layered carbom composite could be used as the external surface of heat exchangers of hypersonic airplanes, in space structures, and as the matrix material in aircraft brake disks.

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* 056
88-1-04.07-9399
Conditions for Thermal-Cycle Testing of Long-Life Radiator Coatings
Boundary Technologies, Inc.
366 Lexington Drive
Buffalo Grove, IL 60089
Robert S. Alwitt (312-537-9399)
JSC -- NAS9-18087

An anodic aluminum oxide coating has been recommended for the Space Station crew systems radiator. Cracking by thermal fatigue is its probable long-term failure mechanism, but it is not clear how to perform accelerated thermal-cycle tests to get a reliable prediction of lifetime. This project will measure the stress and the temperature dependence of stress of anodic coatings. A thermal strain parameter is defined in terms of a temperature of zero stress, T_o. Coatings prepared to have a wide range of T_o are expected to also have a wide range of lifetimes. In Phase I, the extreme values for T_o will be determined experimentally as well as T_o values for two particular coatings for which accelerated thermal cycle test data are available. If it seems feasible to use the T_o criterion as a guide in preparing cycle test specimens, this will be done in Phase II. The cycle test data can then be extrapolated to predict lifetime of operational coatings for known T_o. In Phase II, some particular questions will be examined regarding stability of these coatings in zero-humidity space environment and the possibility of preparing coatings with a structure that improves fracture toughness.

Potential Commercial Applications: The concepts developed in this work will be of value to those working on improved anodic oxide coatings for aircraft.

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* 057
88-1-04.08-5224
Non-Linear Optical Properties of Polyphenylenes
Maxdem, Inc.
267 S. Fair Oaks Avenue
Pasadena, CA 91105
Neil H. Hendricks (818-793-5224)
JPL -- NAS7-1053

Several novel polyphenylene polymers will be prepared and their nonlinear susceptibilities measured. These polymers offer a unique combination of synthetic versatility and electronic properties.

Potential Commercial Applications: Polymers with high third-order susceptibilities are expected to lead to practical applications in optical data processing, communications, and computation.

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* 058
88-1-04.09-6425A
Differential Phase Acoustic Microscopy for Micro-NDE
Bio-Imaging Research, Inc.
425 Barclay Avenue
Lincolnshire, IL 60069
M. Nikoonahadd (312-634-6425)
LaRC -- NAS1-18824

The goal of this project is to demonstrate an acoustic differential-phase microscope. This device, the acoustic counterpart of the Nomarski differential-phase-contrast optical microscope, would be useful for NDE imaging and for characterizing minute variations in the elastic properties of specimens with high lateral resolution, for example, the stress patterns in solids, ion-implanted semiconductors, titanium-titanium diffusion bonds, grains in solids, and composites. A dual-beam acoustic lens provides two adjacent acoustic foci; the phase difference between the signals received from these two foci will result in the image contrast. The Phase I tasks are to identify the samples of interest to NASA, fabricate two dual-beam lenses for surface and subsurface imaging, develop the electronics for driving the dual-beam lenses and for phase sensitive detection, and perform surface and subsurface differential phase imaging at 50 MHz (resolution of 30 μm).

During Phase II the frequency will be extended to 300 MHz for an expected lateral resolution of 5 μm. For Phase III, funding will be sought from commercial manufacturers of acoustic microscopes for a 1 GHz system.

Potential Commercial Applications: In terms of commercialization, this microscope provides a sensitive means for probing the elastic properties of specimens with high lateral resolution.

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* 059
88-1-04.09-7780
NDE Methods for Micro-Structural Characterization of Metal-Matrix Composites
Advanced Research & Applications Corp.
425 Lakeside Drive
Sunnyvale, CA 94086
Robert N. Yancey (408-733-7780)
LaRC -- NAS1-18830

Metal-matrix composite materials, the use of which has grown significantly in the past decade, are being considered for critical components such as turbine engines and primary aircraft structures. Ensuring the integrity of metal-matrix composites is crucial to their use in these critical applications. The strength and lifetime of these materials are determined by the fiber-matrix interface reaction zone and the residual stress state, two parameters which are difficult to measure. Dual-energy microtomography is an innovative method to investigate non-destructively the fiber-matrix region. This project will review current understanding of the characteristics of the fiber-matrix interface and the residual stress state of metal-matrix composites, and experimentally evaluate the feasibility of dual-energy microtomography to measure these characteristics. Design specifications and a conceptual design will also be compiled for a complete non-destructive tomographic, microstructural imaging system for metal-matrix composites for future Phase II development.

Potential Commercial Applications: A microstructural imaging system could apply to commercial development of new materials and aide in the non-destructive inspection of existing structures.

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060
88-1-04.10-0161
Superconducting Fibers of Bi(Pb)-Ca-Sr-Cu-O
LaserGenics Corporation
P.O. Box 611330
San Jose, CA 95161-1330
Richard Schlecht (408-433-0161)
LeRC -- NAS3-25568

High temperature superconductivity has recently become the subject of intense scientific investigation. Present materials are prepared by sintering the oxide powder components and pressing into pellets. This results in a microcrystalline structure that has many disadvantages: the contact between the microcrystals increases the resistance, the composition is not stable, the material cannot be readily formed into useful geometries, and the material lacks strength. This project will investigate the growth of the new high temperature superconducting material, lead doped Bi-Ca-Sr-Cu-O, using the laser-heated, pedestal-growth technique. This technique has a great deal of flexibility and results in fibers that are as pure as the starting material. By controlling the growth atmosphere and growth temperature, the composition and the crystal phase can be controlled.

Potential Commercial Applications: Applications could ensue for motors, generators, computers, electronics, electromagnets, research, and power transmission.

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061
88-1-04.10-1691
Atomic Oxygen Source for Superconducting Thin-Film Fabrication
Ionwerks
2215 Addison
Houston, TX 77030
J. Albert Schultz (713-667-1691)
JPL -- NAS7-1050

The possibility of fabricating superconducting material using a low-energy, high-flux, atomic oxygen source will be explored. The goal will be both to improve the epitaxial growth of superconducting thin films on substrates and to remove the need for harsh annealing in an oxygen environment.

Potential Commercial Application: The commercial benefits of this work would be a technique for the fabrication of superconductors on heat-sensitive substrates such as gallium-arsenide

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062
88-1-04.10-6410A
The Stability of High-Temperature Superconducting Materials in Low-Earth Orbits
Physical Sciences Inc.
635 Slaters Lane, Suite G101
Alexandria, VA 22314
J. T. Schriempf (703-548-6410)
LeRC -- NAS3-25562

The new high temperature superconducting materials are attractive for use aboard spacecraft because components utilizing such materials would require minimal refrigeration. Whether these materials can be used in space depends, in part, on their resistance to the deleterious conditions encountered in the space environment. This project focuses on determining the effects of the atomic oxygen found in low Earth orbits (LEO) upon the material, $YBa_2Cu_3O_x$, which has a critical temperature, T_c, as high as 92 K and can be prepared as a thin or thick film by various techniques.

The approach is to prepare films of $YBa_2Cu_3O_x$ with different initial concentrations of oxygen and to expose these to atomic oxygen bombardment simulating that encountered in LEO. The principal objective will be to correlate damage with oxygen content (in Phase I) to optimize the formulation of the candidate films which will be radiation-hardened for application in the LEO environment (in Phase II).

Potential Commercial Applications: These results could aid in the use of superconducting materials on the surfaces of spacecraft for free-space communications from LEO.

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063
88-1-04.10-9030
Laser Technique in Superconducting Film Deposition
Physical Sciences Inc.
20 New England Business Center
Andover, MA 01810
Christopher J. Rollins (508-477-9030)
JPL -- NAS7-1057

A fabrication method is proposed for deposition of wide-area, homogenous thin films of high-T_c oxide superconductor using a double-pulse, laser-driven, detonation-wave thruster as the deposition source. The device will use laser ablation of bulk superconductors followed by detonation-wave processing and hypersonic nozzle expansion of resulting gases to generate a homogenous atom beam. Films will be deposited on substrates of sapphire, yttrium-stabilized zirconia, and magnesium oxide. Samples will be characterized by structural and chemical analysis, DC resistance and magnetoresistance versus temperature, and AC magnetic susceptibility, using standard techniques.

Potential Commercial Applications: The outcome could be far-infrared detectors and microwave circuits such as low loss transmission lines and filters having significant value in communications applications, both military and industrial, as well as in scientific research.

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064
88.1-04.11-4415
Magnetic Beneficiation of Lunar Soil
Exportech Company Inc.
P.O. Box 588
New Kensington, PA 15068
Robin R. Oder (412-337-4415)
JSC -- NAS9-18092

This project addresses magnetic recovery from lunar soil of ilmenite (source of helium-3, oxygen, titanium, iron, and sulfur), agglutinates (source of elemental iron), glassy components (source of refractory materials), and anorthite (feedstock for electrochemical production of valuable elements such as oxygen, silicon, aluminum, and calcium). Measurements will be made of the magnetic susceptibility and particle size dependencies of the distribution of material recovered from the minus-150-micron-size fractions of five lunar highland and mare samples by dry magnetic separation methods.

In Phase I, a preliminary design will be prepared for a ParaTrap magnetic separator which would be used in Phase II. The separator will be designed for continuous dry beneficiation of feebly magnetic and finely sized lunar soils under conditions simulating the lunar environment. In addition, preliminary designs will be prepared in Phase I for simulants for lunar soils suited for the work of Phase II.

Potential Commercial Applications: The ParaTrap Method could be applied in beneficiation of pulverized coals, recovery of metals from steel processing wastes, and minerals processing. The lunar soil simulants could be used by NASA contractors for lunar engineering studies.

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*** 065**
88-1-04.11-9030
Production of Oxygen and Other Products by Pyrolysis of Lunar Materials
PSI Technology
20 New England Business Center
Andover, MA 01810
Constance L. Senior (508-475-9030)
JSC -- NAS9-18102

The innovation investigated in this project is the production of oxygen by pyrolysis of common lunar minerals using concentrated solar radiation. Oxygen production is possible via pyrolysis of metal oxides because of the formation of gaseous suboxides (or metal vapor) that can be condensed without re-oxidation. This project represents the first attempt to test the pyrolysis concept on simulated lunar material and the first experiment to use concentrated solar radiation as an energy source for vaporization of minerals. In Phase I, the effort will address vaporizing two feedstocks available on the moon (ilmenite and anorthite) with the intent of maximizing the amount of oxygen produced. The experimental program will be complemented by a thermodynamic analysis of the vaporization and condensation phenomena. If successful, Phase I will have demonstrated the feasibility of the pyrolysis of minerals common to the lunar regolith and will have developed guidelines for identifying materials that are most attractive for pyrolysis.

Potential Commercial Applications: The obvious application of this work is to manufacturing in space or in a lunar environment.

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066
88-1-04.12-2010
Sintering of Advanced Ceramic Materials with a Tunable Microwave Cavity
Wavemat, Inc.
44780 Helm Street
Plymouth, MI 48170
Raymond F. Decker (313-454-0020)
LeRC -- NAS3-25608

An existing single-mode, microwave applicator will be employed to investigate ceramic sintering. The applicator design is unique in coupling efficiency and offers internal tuning for single-mode or controlled multi-mode operation. The project will define a large sample matrix in which the sintering parameters are systematically varied. The microstructure of the sintered ceramics will be evaluated and reported. These data will be an important contribution to the literature and an invaluable aid to the design of advanced microwave process equipment and sintering of advanced ceramic-based materials. This will be a

cooperative effort with personnel at Michigan State University who will serve as technical consultants on the project and will provide the support to evaluate the sintered ceramics.

Potential Commercial Applications: Ceramic materials having improved properties could have applications for armor, superconductors, structures, and health care products.

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* 067
88-1-04.12-8476
Improvements to the Laser Float-Zone Process
Penn Laboratories, Inc.
83 Mountain Ridge Road
Cartersville, GA 30120
Wayne Penn (404-974-8476)
LeRC -- NAS3-25605

The float-zone method offers the opportunities for advancing materials technology by producing single-crystal fibers for metal-matrix and intermetallic-matrix composite materials for use in aerospace structures. This project addresses improved processing methods for the production of fibers having low density, high-temperature strength, and high elastic modulus that match the thermal coefficients of and are chemically compatible with metallic and intermetallic matrices. The company, with its investment in the laser float-zone technique and its experience with lasers and controlled processes, is prepared to develop innovations for the production of crystal fibers.

Potential Commercial Applications: Continuous, single-crystal, multiple fibers have applications for aerospace and commercial manufacturing of metal-matrix composite materials.

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05 TELEOPERATORS AND ROBOTICS

* 068
88-1-05.01-0300A
Kinematics Development Tool for Manipulators with Redundant Degrees of Freedom
Odetics Inc.
1515 S. Manchester Avenue
Anaheim, CA 92805
John Forrest Hawk (714-758-0300)
JPL -- NAS7-1055

While several software packages exist for modeling and generating dynamic simulations of general manipulators, no software package simply and automatically provides forward and inverse kinematics which can be used in both real-time controllers and general-purpose simulations. The construction of such a tool is the objective of this project. This tool will provide a simple, reliable means of generating the forward kinematics, Jacobian, and inverse kinematics code for manipulators with any number of redundant degrees of freedom.

Phase I will define the algorithms, the inputs and outputs, the internal language, and the simplification rules used by the kinematics development tool. The tool will be coded and further developed in Phase II.

Potential Commercial Applications: As a symbolic control system code generator, this tool's value will be recognized by the aerospace, nuclear, military, and industrial sectors.

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069
88-1-05.01-0300B
Dual-Arm Collision Avoidance Algorithm
Odetics Inc.
1515 S. Manchester Avenue
Anaheim, CA 92805
Timothy Larson (714-758-0300)
JPL -- NAS7-1038

The challenge of making multiple robotic arm systems work synchronously in a common workspace requires resolution of control issues encompassing collision avoidance, compensation for dynamic forces induced on the payload carried by the arms, and cooperative manipulation of a payload. This project will undertake the definition, development and testing of an algorithm which will determine when collisions are imminent for two robotic manipulators moving in the same workspace. This will enable the manipulators to slow down or stop before a collision occurs. The collision avoidance algorithm will consist of two subsidiary algorithms: the collision feasibility algorithm and the collision detection algorithm. The proposed technique is innovative because the collision avoidance calculations are computationally simple, permitting rapid execution and allowing real-time operation.

Potential Commercial Applications: Applications consist of military systems maintenance and ordnance preparation, in hazardous materials handling, and for maintenance and repair in high-risk situations.

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* 070
88-1-05.01-1225
Discrete Adaptive Control and Adaptive Neural Networks for Robot Manipulators
Netrologic, Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
Dan Greenwood (619-587-0970)
JPL -- NAS7-1058

Robot controllers have concentrated on the use of digital computers with continuous-time, centralized control schemes. Continuous-time operation can lead to degraded performance and instabilities. Centralized control requires extensive computer memory and time to process information from all joints, and it is not fail-safe. The main objective of this project is to develop a discrete-time, decentralized, adaptive control scheme for real-time, digital control of high perform-

ance robot manipulators and to demonstrate its performance. Decentralized (independent joint) control is suitable for parallel processing within a distributed computer architecture. This project will also investigate the applicability of neural network concepts to adaptive control of robot manipulators.

Phase I will be devoted to the development of control schemes, computer simulation, and a feasibility study of adaptive neural network for robot control. Phase II could see the implementation of the control schemes on a PUMA 562 arm and demonstration of its performance.

Potential Commercial Applications: This project could introduce robust robotic controllers for commercial applications, especially in hazardous environments where sensors are expected to fail.

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071
88-1-05.01-5200
Reaction Compensation System for Microgravity Tele-Robots
Sparta, Inc.
4901 Corporate Drive
Huntsville, AL 35805-6201
William Teoh (205-837-5282)
MSFC -- NAS8-38021

A novel reaction compensation system is an answer to the needs of designing robotic systems that are reactionless. Any robotic system for use in the Space Station must be reactionless so as not to disturb the acceleration environment it is in. The feasibility of designing and subsequently building a reaction compensation system (RCS) will be investigated. Personnel at the company have developed several preliminary concepts. These concepts will be further studied, culminating in the selection of a single design that is cost effective and meets the above-mentioned needs.

Potential Commercial Applications: Reactionless robots would apply to microgravity experiments, manufacturing, and space industrialization.

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* **072**
88-1-05.01-5600
A Visual Language, Telerobotic Operator Interface for Rapid Implementation of Autonomous Tasks
TeleRobotics International, Inc.
8410 Oak Ridge Highway
Knoxville, TN 37931
H. Lee Martin (615-690-5600)
LaRC -- NAS1-18823

Space construction and satellite servicing activities require machines that can perform human manipulation without the actual presence of an astronaut. Advanced manipulation would benefit from incorporating the human thought process into the autonomous procedures used by robotic systems. This project addresses the use of visual language communications to enhance the interface between the human operator and the manipulator. This visual language will allow the rapid modeling and integration of manipulation, sensing, and decision making by creating a flowchart of the activities and the decision process. The integrated software system accomplishes the rest by writing coded instructions.

Phase I applies the company's previous visual language developments including the demonstrated ability to control multiple manipulator arms. This innovation will incorporate sensory systems to aid in the autonomous decision making for telerobotic applications.

Potential Commercial Applications: A visual language interface for real-time process control has unlimited commercial prospects as indicated by the market for the company's commercial visual language now used in 22 countries as an interface for computer-based training (in French, Nordic, and Japanese versions).

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073
88-1-05.01-8024
A Perception System for Object Recognition, Acquisition, and Tracking in Cluttered Environments
Intelligent Recognition Systems
6925 Canoga Ave., Suite 102
Canoga Park, CA 91303
Jerry A. Burman (818-702-4762)
MSFC -- NAS8-38047

The use of human resources in space can be made more efficient with the aid of intelligent systems which can perform intricate or mundane tasks with minimal human interaction through a flexible man-machine interface. This project will develop a sophisticated perception system that can be integrated with a variety of imaging sensors and is capable of autonomously recognizing objects from arbitrary, three-dimensional perspectives. In addition, the system will be capable of autonomous or operator designated object acquisition and tracking in cluttered environments against stationary or moving objects.

The Phase I effort will establish the preliminary requirements for the system and concentrate on critical elements of the perception system: object recognition, acquisition, tracking, and operator interface. A simulation will be developed to demonstrate the key aspects of the system using artificially generated image data. The simulation should validate the basic building blocks of the system and bound its overall performance.

Potential Commercial Applications: Uses could include quality control inspection systems for manufacturing, robotic control for product assembly, and automated security systems.

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074
88-1-05.01-8500
A Single-View, Three-Dimensional Object Recognition System
KMS Fusion, Inc.
3853 Research Park Drive - Box 1567
Ann Arbor, MI 48106-1567
Theodore B. Ladewski (313-769-8500)
LaRC -- NAS1-18814

NASA needs robust, accurate, and efficient three-dimensional vision systems for Space Station construction, maintenance, and operations. These vision systems must be able to operate reliably in cluttered environments having poor natural illumination and containing potentially many different objects which may be in relative motion. Existing vision systems using cameras are too inflexible and slow. Similarly, systems employing laser range finders are slow and suffer from severe signal-to-noise problems. To address these needs, a state-of-the-art object recognition system will be developed which: determines object type, location, and orientation from a single view; operates in poorly lit environments cluttered with many occluding objects; can detect a wide range of objects stored in its database; is fast enough to track object movement between frames; and can use rugged, reliable hardware.

Potential Commercial Applications: Industrial applications include automatic inspection, assembly, maintenance, and obstacle avoidance.

***

075
88-1-05.03-0718
Centerline Imaging System for End-Effector Tools
Olis Engineering
Box 408
Sedalia, CO 80135
Carter K. Lord (303-688-0718)
MSFC -- NAS8-38029

The purpose of this project is to develop a true centerline imaging system for use with end-effector tools. The need for this type of imaging system was identified during the course of a previous study to develop inflatable end effectors for handling delicate composite structural components. An inflatable end-effector tools shows promise for the addition of a centerline imaging system with minimum redesign of the end-effector tool. This project will design a centerline imaging system for that end-effector tool, fabricate a prototype of the end-effector tool with the centerline imaging system, and test the system at a NASA facility that is compatible with the proposed innovation.

Potential Commercial Applications: This system could apply to the use of teleoperators for military systems, space construction and servicing, marine exploration, hazardous material handling, and salvage operations.

***

* 076
88-1-05.03-1100
A Parallel Processor for Simulating Manipulators and Other Mechanical Systems
Electronic Associates, Inc.
185 Monmouth Parkway
West Long Branch, NJ 07764
George Hannauer (201-229-1100)
GSFC -- NAS5-30497

As mechanical systems such as manipulators and actuators become more complex, the computational burden makes it increasingly difficult to maintain a real-time solution for simulation in design or real-time control. This project deals with an innovative, parallel-computer architecture for simulation of mechanical systems that has evolved from analog rather than von Neumann digital computers. As such, it offers a considerable improvement in speed; preliminary estimates indicate it is 10 to 100 times faster than conventional architectures. The design has been validated for a small version of the architecture consisting of a single module (a small number of tightly-coupled processors). In Phase I, a version with several modules will be evaluated. Solution speed would be increased by modifying the scheduling algorithms. The extended architecture will be investigated by programming several applications to obtain detailed speed comparisons with conventional architectures. The principal Phase II effort is to construct a prototype to verify the Phase I timing assumptions.

Potential Commercial Applications: A method for rapid, low-cost simulation of mechanical systems could have uses for the design of automobiles, aircraft, missiles, power generators, and many other products.

***

077
88-1-05.03-1391
Torque-Balanced Drives for Space Station Applications
Nastec, Inc./Transmission Research, Inc.
10823 Magnolia Drive
Cleveland OH, 44106
William J. Anderson (216-231-6570)
LeRC -- NAS3-25576

To eliminate dynamic disturbances to the Space Station and its on-board experiments, it would be desirable to provide actuator drives and drives for dynamic experiments which have a zero net output torque. This can be accomplished by utilizing drives with dual, counter-rotating, torque-balanced outputs. The innovation is a planetary traction drive with dual, roller clusters each feeding an output. The two outputs are at equal speed and torque and opposite rotation. A specific drive ratio, torque requirement, and speed will be studied in Phase I. Drive kinematics, size, life, and expected performance will be defined. A final design and manufacturing drawings will be completed. A test program for Phase II will be delineated.

Potential Commercial Applications: Uses could be for torque-balanced drives for scientific instruments and dual drives for propulsion systems.

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078
88-1-05.03-5649
Lightweight, Permanent-Magnet Actuators and Manipulators
Advanced Materials Corporation
(c/o Mellon Institute)
4400 Fifth Avenue
Pittsburgh, PA 15213-2683
E. B. Boltich (412-268-5651)
MSFC -- NAS8-38044

Permanent magnets based on $Nd_2Fe_{14}B$ and $Pr_2Fe_{14}B$ exhibit very high magnetic-energy-products at room temperature. Slight modifications of these compositions by adding cobalt and aluminum have extended their utility over a wide temperature range. For example, a Pr-Fe-B magnet recently produced in the firm's laboratory exhibited a high energy-product which translates into a higher torque-to-weight ratio for many electro-mechanical systems. Phase I includes design studies and development of prototypes of limited-displacement actuators and reluctance position sensors equipped with Pr-Fe-B permanent magnets. These devices are expected to function smoothly and reliably over a wide temperature range in electro-mechanical systems for telerobots. In view of their high torque-to-weight ratio, they are expected to reduce the mass required for certain space applications.

Potential Commercial Applications: Low-weight, permanent magnets could be used for robot motors, instrumentation for medical applications, automobile parts, and electro-hydraulic actuators in aircraft.

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079
88-1-05.03-7070
Composite, Six-Axis Force Sensor with Embedded Optical Sensors
Geo-Centers, Inc.
7 Wells Avenue
Newton Centre, MA 02159
Bruce N. Nelson (617-964-7070)
GSFC -- NAS5-30455

Sensory feedback is required to allow robots to perform complex tasks in unstructured environments. Six-axis force sensors are used to monitor the forces acting between a robotic gripper, tooling bit or other device, and the robot arm. Electronic sensors are limited in dynamic sensing range and are sensitive to the adverse effects of electromagnetic interference. Additionally, strain gauges sensors can separate from their supporting structure and render the six-axis force sensor useless. This project investigates the feasibility of an optical, six-axis force sensor fabricated from composite materials (fiber-reinforced, organic matrix) with embedded optical sensors for strain sensing. This novel technique will circumvent many of the difficulties associated with electronic sensors.

The Phase I effort will determine the effect of composite material cross-section, the composite material, and the optical-strain-gauge configuration on the performance capabilities of single-axis force sensors. An optically based six-axis force sensor will be designed, fabricated, and evaluated as part of the Phase I program.

Potential Commercial Applications: Six-axis force sensors for robots could find commercial applications in the automotive, aerospace, and general manufacturing industries.

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080
88-1-05.03-8822
Cableless Power and Signal Transfer for Robot End-Effector with Integrated Sensor System
Automated Dynamics Corporation
105 Jordan Road
Troy, NY 12180
David Hauber (518-283-8822)
LaRC -- NAS1-18808

Cables used for both power and signal transfer across the wrist joints of robotic end effectors can limit rotation of the wrist, decrease reliability, and interfere with arm motion. It should be feasible to transmit signals along with power on two wires through the wrist joint without physical contact by means of a rotary transformer. The effective bandwidth can be extended by placing "intelligent" functions on the end effector and transmitting only high-level command and control sequences providing that the sensors and actuators on the robot end-effector are fully integrated. This project involves designing the transformer for optimal data transfer in terms of bandwidth and error detection and correction, developing a compact, rugged controller for the end-effector, and integrating end-effector functions with the controller. After demonstrating the cableless end effector-control in Phase I, Phase II would focus on miniaturizing, ruggedizing, and extending the available functions and would bring the system to market for government and industrial applications.

Potential Commercial Applications: Applications are those that require reliable data acquisition and control capabilities on continuously rotating systems such as turrets, rolling mills, and turbines.

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081
88-1-05.03-9200
Parallel Implementation of Algorithms for Robotic Sensory Fusion
Perceptics Corporation
725 Pellissippi Parkway
Knoxville, TN 37933-0991
R. C. Gonzalez (615-966-9200)
GSFC -- NAS5-30459

This project focusses on the parallel implementation of algorithms for robotic sensory fusion involving the use of multiple sensors such as video, range, proximity, touch, force, and torque. The innovation in this project is the parallel multi-sensing as well as the parallel processing of sensory cues to allow fast identification of objects in realistic work spaces in order to perform authentic robotic tasks. The need for this sensory and computer technology cuts across the board of NASA activities including deployment, maintenance, and repair missions. The equipment necessary for the execution of this project is in place. The firm has recently integrated one of the largest massively parallel computers in the nation: a 1024-processor NCUBE hypercube. A versatile and complete robotic workstation equipped with all the sensors necessary for this project is available at the University of Tennessee. As a result, the chances of technical success and likelihood of commercialization of the outcome are high.

Potential Commercial Applications: Applications could result from implementation of specific sensory algorithms in a hypercube computer, a principal architecture in the field of massively parallel machines.

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*** 082**
88-1-05.04-5900
Robotic Adaptive Grasping with a Capacitance-Array Tactile Sensing System
Extrude Hone Corporation
8075 Pennsylvania Avenue
Irwin, PA 15642
Donald G. Risko (412-863-5900)
JSC -- NAS9-18093

Adaptive grasping of various objects by a single end-effector is required for robots designed to operate in space. A sensor system that can be integrated with a flexible end-effector to provide target recognition and controlled gripping is the focus of this project. Basic research conducted by the proposer on capacitance sensor technology indicates that capacitance between a sensor and a target can produce tactile information. Furthermore, capacitance sensors are light weight and robust, thereby making them excellent candidates for space robotic systems.

Phase I will investigate the applicability and environmental suitability of a capacitance sensing system to space robots. An adaptive-control philosophy and limitations will be established. Phase II would establish and demonstrate an adaptive grasping system with the objective of obtaining the maximum of information from a single sensor (or array of sensors) with minimal reliance on sensor fusion schemes in order to reduce the complexity of hardware and software.

Potential Commercial Applications: Intelligent machine applications via real-time sensor feedback could be applied to sophisticated tasks, such as assembly.

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*** 083**
88-1-05.04-8622
Sensor-Based, Whole-Arm Manipulation for Adaptive Grasping
Intelligent Automation Systems, Inc.
300 Bent Street, Suite 200
Cambridge, MA 02141
Steven J. Gordon (617-354-3830)
JSC -- NAS9-18097

This project involves the design of a novel manipulation system which can control contacts with objects along all surfaces of its links. This whole-arm manipulation (WAM) system is capable of grasping and manipulating a varied set of objects far larger than the set which may be manipulated by a conventional arm using an attached gripper. Recently developed tactile sensing technology and joint-torque sensing will allow the WAM manipulator to control multiple contacts stably anywhere along its links. The objectives for Phase I are to determine important space and terrestrial based tasks for an autonomous or telerobotic hand-arm system, assess the state of the art in WAM and tactile-sensing technology, perform analyses and an experiment on an existing WAM manipulator to determine the accuracy of integrating joint-torque and tactile sensor information to control a WAM arm, and propose specifications for a WAM system design.

Potential Commercial Applications: Uses consist of performing tasks in hazardous and unstructured environments, assembling parts, maintaining underwater systems, and emulating human limbs.

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*** 084**
88-1-05.05-2200
An Automated Wire Guide for Robotic Welding Applications
General Digital Industries, Inc.
6705 Odyssey Drive
Huntsville, AL 35806
Troy D. Manley (205-837-2200)
MSFC -- NAS8-38024

While much effort has been expended recently in automatic control of processes for robotic welding of space structures, the positioning of the weld wire remains dependent on a human operator. Because misalignment of the weld wire can result in defects that are difficult to detect, the process is subject to the vagaries of all human-controlled operations: inattention, varying experience level among operators, and failure to take timely action. An automated weld wire guide is proposed to position the wire as the arc is established and maintain proper position in spite of varying cast of the wire, height of the surface, departures from seam center, and other changes in situation that now require human intervention.

The Phase I effort will determine the functions and requirements for an automated wire guide for robotic welding of the berthing ports of the Space Station. It will determine the feasibility of implementing a guide

using available sensors, process and motion control algorithms, and artificial intelligence technology.

Potential Commercial Applications: Applications would be in automated welding equipment for reasons of productivity or quality control.

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* 085
88-1-05.05-4502
An Artificial Intelligence System for Process Monitoring, Situation Assessment, and Response Planning
Seer Systems, Inc.
119 Cardiff Road
Pittsburgh, PA 15237
Harry E. Pople, Jr. (412-366-4502)
JSC -- NAS9-18104

The innovation being addressed in this project is a new architecture for artificial intelligence systems called Eagol. Unlike typical artificial intelligence shells, this system incorporates a strong reasoning model derived from detailed cognitive studies of decision making in a variety of arenas, including internal medicine diagnosis, operations of nuclear power plants, and intelligence analysis. Principal features of the language include capabilities for situation assessment, generation and tracking of expectations-based experiential knowledge (cast in the form of scenarios), as well as first-principles cause and effect reasoning. Applications developed within the Eagol framework can incorporate strategies for response planning and closed-loop disturbance management. The principal objective in this investigation will be to discover whether the innovation represented by Eagol can be employed usefully in applications of interest to NASA.

Potential Commercial Applications: Applications could be found in process diagnosis and intervention and in decision support systems.

***

086
88-1-05.05-4917
An Automatic Scheduling Assistant for the NASA Space Station
Innovative Research, Inc.
6735 East Sixth Avenue
Denver, CO 80220
Mohsen Pazirandeh (303-321-4917)
JSC -- NAS9-18114

Since the initial phases of automation for the proposed NASA Space Station will be centered around teleoperated robots, the crew will play an integral part and will have to schedule activities subject to the constraints of material and labor resources. The subject of this project is an automatic scheduling assistant based on a hierarchy of activities in which the activities of high criticality are scheduled prior to those of lower criticality. Furthermore, each criticality level is considered to be a potentially different class of scheduling problem with an associated set of scheduling rules. To assess the feasibility of this approach, Phase I will attempt to show that there exist goal-directed approaches for selecting a criticality hierarchy for scheduling Space Station activities and for classifying scheduling problems at each level and that there is a corresponding set of scheduling rules for each class.

Potential Commercial Applications: The automatic scheduling assistant could schedule activities aboard Space Station so that experiments and manufacturing processes will be conducted with minimum cost.

***

* 087
88-1-05.05-5500
Compiling Knowledge-Based Systems Specified in KEE to Ada
IntelliCorp Inc.
1975 El Camino Real West
Mountain View, CA 94040
Robert E. Filman (415-965-5500)
MSFC -- NAS8-38036

Artificial intelligence techniques have become important for the solution of some of the most difficult programming tasks. The dominant approach for developing such applications is to work in a multi-mechanism, integrated, knowledge-based system development environment, such as KEE or ART. Unfortunately, systems developed in environments such as these are inappropriate for regular use in many applications, particularly those germane to space systems. They are not real-time, they carry the baggage of the entire Lisp environment, and they are not written in Ada. This project will perform innovative work on compiling dynamic, symbolic structures to conventional environments and on creating the appropriate interfaces and environments to aid in the translation and maintenance of Lisp-defined and Ada-executed systems.

Potential Commercial Applications: Expert system applications developed in KEE and delivered in conventional environments such as Ada could satisfy strong commercial and governmental demands.

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088
88-1-05.05-7300
The Space Station as Robot: A Reactive Planning Approach to OMS Problems.
Advanced Decision Systems
1500 Plymouth Street
Mountain View, CA 94043-1230
Daniel G. Shapiro (415-960-7557)
JSC -- NAS9-18083

The Operations Management System (OMS) for the Space Station possesses many of the attributes of a robot; it has sensors, effectors which command station subsystems, and a plan. As with a robot, the OMS must adapt to changing circumstances, identify responses to fault conditions, and represent plans in

a manner that allows for adaptivity. The OMS must also assess the consequences of possible actions. The purpose of this project is to address these OMS problems and provide a prototype of a solution based on three technologies being developed by the company: an architecture for reactive plan execution, a plan representation which implements response modes with limited sensing and action authority, and an impact assessment technique which operates by heuristic simulation of the plan.

In Phase I, the relevance of these reactive planning techniques to the OMS problem will be assessed and high-level prototype design will be provided. In Phase II we will build a prototype that solves key portions of the OMS problem.

Potential Commercial Applications: This project could provide key components of Space Station Operations Management System.

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06 COMPUTER SCIENCES AND APPLICATIONS

* **089**
88-1-06.02-4242A
Expert Assistant for Integrated Timing and Reliability Design Analysis
Advanced System Technologies Inc.
12200 E. Briarwood Avenue, Suite 265
Englewood, CO 80112
Robert Goettge (303-790-4242)
GSFC --- NAS5-30502

Timing and reliability performance characteristics, critical characteristics of embedded-computer system software, involve complex tradeoffs during design to ensure that systems will satisfy stringent performance requirements. This project will investigate an expert-system-based, automated tool to analyze complex software systems for timing and reliability performance. Heuristic or self-educating aspects of the tool's knowledge base will address the complexity of design analysis. Coupled with a performance modeling component, the expert system will assess compliance with requirements, identify performance problems, and recommend design changes. An open knowledge base will permit easy enhancement by experts.

Phase I will structure the body of knowledge about software timing and reliability performance and will define the expert system utilities required to support the concept of an open knowledge base. Previous research with integrated timing and reliability modeling and with expert system applications for timing analysis will provide a base for the open, integrated expert assistant.

Potential Commercial Applications: The results could aid the development of complex, time-critical computer systems by government agencies and commercial groups conducting on-line transaction processing.

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090
88-1-06.02-7910
Reusable Software Base Development--Source Code Tailoring
AKM Associates Inc.
625 Mariner's Island Boulevard, #205
San Mateo, CA 94404
Carl Ponder (415-571-7910)
GSFC --- NAS5-30488

One of the most promising software engineering concepts to increase programmer productivity is reuse of existing, proven software. A general program, the archetype source, can be adapted to a broad spectrum of specific situations. An example is a program for multi-sensor integration which can be adapted to various combinations of sensors. Ada and other high-level languages offer abstractions for writing general forms of programs for adaptation on a case-by-case basis. In this project, a tailoring system utilizing abstractions in a metanotation for describing an archetype source and its specific forms will be shown to be quite powerful in the context of the derivation of application-specific actual sources from the general program.

The Phase I approach will be to define an archetype-source version of an existing application-specific software that the firm built for NASA-JPL and to develop the metanotation for generating the actual source. The project could lead to better understanding of automated program generation, abstract program constructs, program reuse, and adaptability.

Potential Commercial Applications: Applications could occur where several platforms or equipments perform a common set of functions with variations in regard to sensors and communication interfaces.

***

091
88-1-06.03-2595
Enhanced Condition Tables for Verification of Fault-Tolerant Software
SoHaR Inc.
8500 Wilshire Boulevard, #1027
Beverly Hills, CA 90211
Herbert Hecht (213-855-2595)
LaRC --- NAS1-18811

The goal of this project is to develop a feasible, credible, economical, and thorough verification methodology for fault-tolerant software. While it could be assumed that existing verification techniques could be adopted, fault-tolerant software poses a unique verification problem of ensuring that the hard core is error-free under all anticipated execution states. The hard core is that portion of the fault-tolerant software which is not redundant and which must execute properly each time it is invoked. The acceptance test in a recovery block is an example.

The firm has developed a verification technique for hard cores called the enhanced condition table (ECT). The project will investigate the feasibility of the ECT for larger development efforts by exercising it on a

portion of a fault-tolerant, distributed, nuclear reactor control system now being developed by the company. Tools running under UNIX with a graphical interface will be developed during Phase II based on the prototypes developed in Phase I. The effort should be of interest to all NASA space missions.

Potential Commercial Applications: These tools can be sold to all developers of real-time control systems with life-critical applications.

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*** 092**
88-1-06.03-3370
Reliable Specification for Ada Software
Software Productivity Solutions Inc.
PO Box 361697
Melbourne, FL 32936-1697
Andres Rudmik (407-984-3370)
LaRC --- NAS1-18826

This innovation focuses on techniques and tools that will dramatically improve software reliability through a systematic approach for fault avoidance. The approach is based upon a reliable specification technique that supports the formal, incremental, and humanly verifiable description of system behavior; a systematic set of transformations of the specification to implementations of object-oriented Ada software systems that are highly reliable; and the integration of this new reliable development process with existing advanced verification, validation, and testing approaches.

The proposed Phase I effort will define a comprehensive fault-avoidance methodology. A sophisticated, automated tool-set, to be developed as a prototype during Phase II, will support the efficient development of highly reliable Ada software.

Potential Commercial Applications: A fault-avoidance methodology and automated tool-set could be used for mission-critical software and for nuclear power control, commercial airlines, and certain processes that have stringent reliability requirements.

***

093
88-1-06.04-6364
Applied Research of KBS Technologies for Advanced Decision Support Systems
ECON Inc.
4020 Moorpark Avenue, Suite 216
San Jose, CA 95117
John P. Skratt (408-249-6364)
ARC --- NAS2-12963

In a process analogous to applied research, this innovation applies knowledge engineering technology in order to develop an advanced decision support system. By combining the company's knowledge of current NASA requirements and expertise, this project will extend applied knowledge engineering in the areas of global understanding, representation, and control of multiple, domain-independent knowledge bases; integrated data bases for distributed knowledge bases; hierarchical control architectures for distributed knowledge bases; and system relationships that are understandable and accessible to humans at a high level of communication.

Potential Commercial Applications: An advanced decision support system could support NASA in a variety of assessments currently facing the agency.

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094
88-1-06.05-3370
Design Knowledge Capture
Software Productivity Solutions Inc.
PO Box 361697
Melbourne, FL 32936-1697
Vincent J. Kovarik (407-984-3370)
MSFC --- NAS8-38027

The capture of design knowledge is currently a human-intensive paper process that offers little or no automated assistance to the developer. The innovation represented by this project is a software-development, design-knowledge server. This server functions as a persistent object base, retaining not only the products of a development effort, such as the documentation, reports, and code, but also the rationale behind the decisions within the development process and the domain knowledge that supports the decision. This provides a continuum of knowledge as reasoning that may be utilized by subsequent developers, maintenance personnel, and management.

Potential Commercial Applications: Applications would derive from the inclusion of this technology into software developments of government contractors, government agencies, and commercial groups.

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*** 095**
88-1-06.06-1625B
SimTool--An Integrated Graphics and On-Orbit Vehicle Dynamics Simulation Tool
LinCom Corporation
1020 Bay Area Blvd., Suite 200
Houston, TX 77058
Randall D. Barnette (713-488-5700)
JSC --- NAS9-18099

There is a demand for improved graphics capabilities for real-time, vehicle-dynamics simulation. However, no system exists which integrates the capabilities of a state-of-the-art graphics interface with a state-of-the-art vehicle simulation tool into a single engineering and flight operations tool. The innovation, SimTool, will integrate existing state-of-the-art graphics and vehicle-dynamics simulation architectures via automatic code generation and integration resulting in an advanced engineering workstation with applications for real-time flight trainers, human factors research, engineering analysis, flight planning and operations, and on-board expert systems. SimTool will allow a

user to configure, in a single process, a customized, multiple, active, vehicle simulation with real-time graphics and high-fidelity dynamics without programming a single line of source code.

Potential Commercial Applications: Applications could be in multi-vehicle traffic control, MIL training and performance, high-fidelity dynamics control and performance, and on-board expert systems.

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* 096
88-1-06.06-4570
A Cognitive Neurocomputer for Mission Planning and Control
Martingale Research Corp.
100 Allentown Parkway, Suite 211
Allen, TX 75002
Robert L. Dawes (214-422-4570)
JSC --- NAS9-18100

This project utilizes a neural network to implement an identification and control computer for nonlinear dynamical systems. This neurocomputer, called the Parametric Avalanche, will integrate sensor data from arbitrary arrays of sensors, detect space-time patterns, and synthesize actuator responses to those patterns consistent with mission objectives and system survivability. The proposed design implements a generalized Kalman filter on signals of large dimensionality representing nonlinear dynamical systems in non-Gaussian noise--a feat which is computationally intractable on the most powerful non-neuromorphic computers. It is also capable of environmental control interactions which exhibit the properties of true machine cognition.

Potential Commercial Applications: This product could be applicable to parallel signal processing and adaptive problems such as collision avoidance, control of articulated structures, semi-autonomous vehicle guidance, and industrial process control.

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097
88-1-06.07-1467
Optical Drum for Space and Ground Applications
Systolic Technology Inc.
883-A North Shoreline Blvd.
Mountain View, CA 94043-1940
John R. Wilson (415-962-1467)
ARC --- NAS2-12964

This project seeks to define the design envelope for an optical-drum-storage device utilizing phase-change optical media. Whereas media development has progressed satisfactorily, a feasible mechanical design of a drum employing this media remains to be established and is the goal of Phase I. An engineering model would be constructed in a subsequent phase. The unique mechanical design proposed for the drum has many benefits, including stability, compactness, and ruggedness necessary to support use of the device in either ground-based or spacecraft applications. The proposed configuration will have a maximum capacity of 53 gigabytes and an access time below 6 milliseconds. The projected physical volume of the proposed device is about one cubic foot. This effort is expected to result in the creation of a new class of high-performance storage devices using low-cost optical media.

Potential Commercial Applications: Applications could be for large, temporary storage buffers with high transfer rates for use with supercomputers, for archival storage of large quantities of scientific, engineering, and satellite imagery data, and for large, complex software systems.

***

098
88-1-06.07-3200
A System Library Facility for Parallel Computers
Expert-Ease Systems Inc.
1301 Shoreway Road, Suite 420
Belmont, CA 94002
John O'Reilly (415-593-3200)
ARC --- NAS2-12968

This innovation addresses the design, development, and implementation of MathCOMMAND, a set of systems software routines to aid the efficient execution of large-scale scientific and engineering computations on parallel computers. The goal of this project is to determine methods of making the raw computing power of parallel computers available to physicists and engineers. The system software will consist of a library of highly parallel software routines together with a specialized programming environment tailored to specific applications domains.

Potential Commercial Applications: This software could facilitate the use of parallel computers and may have a wide market in providing additional computing power to scientists and engineers.

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* 099
88-1-06.08-4448
VME Rollback Hardware Modules for Time-Warp Microprocessor Systems
Integrated Parallel Technology Inc.
PO Box 908
Campbell, CA 95009
Calvin Buzzell (408-866-4448)
JPL --- NAS7-1046

The purpose of this Phase I effort is to develop and demonstrate innovative hardware to implement specific rollback and timing functions required for efficient queue management and precision time keeping in multi-processor, discrete-event simulation. In order to support simulations of large-scale discrete events, the approach will be to form a breadboard of multiple, custom VME boards, referred to as queueing elements, and a global virtual time module. A test stand will demonstrate the feasibility of implementing a rollback, very-low-overhead, state-saving mechanism

on integrated, VME modules for application with a hypercube multi-processor.

Potential Commercial Applications: Commercial applications could be in the design of work stations and large-scale simulations.

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07 INFORMATION SYSTEMS AND DATA HANDLING

* 100
88-1-07.01-5000
KBS/DSP Image-Coding System
Odetics Inc.
1515 S. Manchester Avenue
Anaheim, CA 92805
George B. Westrom (714-744-5000)
LaRC --- NAS1-18816

An intelligent, image-coding system for data compression involving a knowledge-based system (KBS) and digital signal processing (DSP) will have wide application in space, military surveillance, and commercial systems. This project is specifically directed at the needs for monitoring micro-gravity experiments where the massive amount of data generated far exceeds storage and transmission capabilities. The objective is to combine KBS and DSP technology so as to extract and transmit the important data in a timely manner. The work conducted will demonstrate feasibility both with an analysis of specific DSP performance and demonstration of a prototype KBS. A number of coding methods will be used including loss-less coding, transform coding, and feature extraction. Phase II would see the development of a KBS/DSP coding system which will be used to evaluate Space Station and other application areas.

Potential Commercial Applications: This work could apply to image communication systems, factory robotics and processes, and security systems.

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101
88-1-07.02-0094
Polarimetry-Based, SAR Shape from Shading for Terrain Reconstruction
Vexcel Corporation
2905 Wilderness Place
Boulder, CO 80301
Franz W. Leberl (303-444-0094)
GSFC -- NAS5-30596

This project is directed toward the development of algorithms and software which incorporate polarization data into techniques for terrain reconstruction using shape-from-shading in multiple-image, synthetic-aperture-radar (SAR), quadpole data. This represents an innovative approach to the problem of resolving the ambiguities inherent in attributing the changes in SAR-image shading to either actual changes in terrain slope or to changes in scattering cross section. This solution will combine complex polarization data with spatial data to achieve higher resolution terrain reconstruction from SAR data than can be obtained by radar stereo techniques alone.

Potential Commercial Applications: Applications could be in high resolution terrain mapping to support geophysical prospecting.

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102
88-1-07.02-1225
Adaptive Image Encoding and Classification Using Neural Networks
Netrologic Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
Richard S. Cigledy (619-587-0970)
GSFC -- NAS5-30481

The viability of neural networks is explored for image compression and pattern classification in an integrated system. This new approach to image compression has several advantages over standard approaches. So far, research indicates that neural networks are comparable to standard techniques for the task of image compression. A three-layer, back-propagation network with essentially no tuning has demonstrated levels of compression on the order of 1 bit per pixel (bpp). This project will attempt to achieve compression rates below 1 bpp and investigate its usefulness in NASA applications. If the algorithm can be embedded in hardware, the potential advantages for space-based applications are a compression device that adapts to the current environmental and hardware conditions, operates in real time with reduced sensitivity to channel errors, and is a reconfigurable pattern classifier that can be trained in situ.

Potential Commercial Applications: An adaptive image processor could be applied in medical pattern recognition devices for such uses as detecting tumors in chest radiographs and counting blood cells in blood samples.

***

103
88-1-07.02-3503
A Neural Network Approach for Unsupervised Image Classification
Multisignal Technology Corp.
4662 Katella Avenue, Suite J
Los Alamitos, CA 90720
Thinh V. Nguyen (213-431-3503)
SSC -- NAS13-381

Unsupervised image classification and clustering could benefit remote sensing of Earth resources and land use and landing site analysis in space exploration. This Phase I project investigates this opportunity using neural network technology. The objectives

include the development of feature extraction techniques, neural network learning and clustering procedures, and proof-of-concept simulation. The image features are first extracted to become the input patterns to the neural network. The learning procedure is iterative and based on the back-propagation paradigm. The clustering process is carried out by merging regions based on a minimum error criterion. The classifier and the learning algorithms developed in this Phase I will be used for many image-analysis tasks especially in image clustering and segmentation. The Phase II efforts will be more comprehensive and thorough including the development of algorithms to utilize multi-spectral and spatial image contents, the design of a generic neural network classifier, and the construction of a complete image analyzer.

Potential Commercial Applications: The results of this project could apply to scene analysis and target recognition and tracking for military operations and to localization and identification of parts in industrial robotics.

***

104
88-1-07.03-8707
Statistical Tools for Spatial Processes
Statistical Sciences Inc.
PO Box 85625
Seattle, WA 98145-1625
Stephen P. Kaluzny (206-322-8707)
SSC -- NAS13-383

During the last few years there has emerged a clear perception of the pervasive importance of spatial statistics throughout many scientific and engineering fields having considerable national interest. For example, spatial statistics play a crucial role in such diverse fields as remote sensing, image processing, mining, multiple target detection and tracking, etc. At the same time, many of the major contributions to the foundations of spatial statistics have been made outside the U.S. This project focuses on three specific topics within the field of spatial statistics: modeling and estimating spatio-temporal stochastic processes; jackknifing and bootstrapping; and smoothing spatial data and computing linear parts of two-dimensional, robust smoothers. In addition, the methodologies will be embedded into the interactive statistical language and system, S-PLUS. Initial studies will be carried out on the development of powerful, graphical display techniques for analyzing spatial processes in the S-PLUS environment.

Potential Commercial Applications: Projected uses are in automatic tracking, inspection and identification, surveillance, remote sensing, and medical imaging.

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*** 105**
88-1-07.04-1225
A Natural Language Interface to a Geographical Information System
Netrologic Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
Rachel Adar (619-587-0970)
SSC -- NAS13-384

Phase I will develop a preliminary design of a natural language interface to a geographical information system (GIS). The design will be based on state-of-the-art, artificial intelligence, natural language, and dialogue modeling. Phase I will study a number of different GISs and their users by focusing on the relation, if any, between a requisite natural language interface and the underlying architecture of a GIS and by surveying the functionalities of the systems to determine an appropriate knowledge base which the natural language interface will span. The natural language interface work will also focus on establishing clear delineations between the inferencing to be handled by the language module and that to be left in the hands of an underlying GIS. Architectural decisions for the natural language module and its interface to the GIS will be included in the design. The language module will also include a dialogue system for extended human-machine problem solving using a GIS. Most of the details of the dialogue system and any implementation will be left for Phase II.

Potential Commercial Applications: A natural language interface could apply, with minor modification, to a number of geographical information systems.

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*** 106**
88-1-07.05-0300
A Multichannel, Acoustic-Optic Bragg Cell RF Spectrum Analyzer System
Newport Electro-Optics System Inc.
4451-B Enterprise Court
Melbourne, FL 32935
Eddie Young (407-254-0300)
GSFC -- NAS5-30486

A multichannel, acousto-optic, Bragg cell spectrum analyzer offers a solution to the processing of wide-bandwidth RF spectral information. Acousto-optic spectrum analyzers are used in military electronic warfare and electronic intelligence applications. The extension of this technology to a two-dimensional, N-channel, Bragg cell processor gives an N-fold increase in bandwidth capability, which is necessary for NASA's application. The objectives of this project are to demonstrate the multichannel, acousto-optic, Bragg cell spectrum analyzer concept and demonstrate the long integration time required for NASA's applications. Once this system is successfully demonstrated, it is possible to address other NASA ground and space-borne applications that can utilize this acousto-optic spectrum analyzer system.

Potential Commercial Applications: The outgrowth of this technology could be applicable to optical computing and image processing.

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* 107
88-1-07.05-4429
Fiber-Optic Interconnection Networks for Spacecraft
Optivision Inc.
744 San Antonio Road, Suite 10
Palo Alto, CA 94303
Antonio R. Dias (415-852-9931)
GSFC -- NAS5-30501

Fiber-optic devices have great advantages in reducing weight, size, power requirements, and electromagnetic interference effects when used to interconnect sensors, processing modules, and communication, control, and storage devices in spacecraft or space platforms. Optical fiber systems can integrate these devices in a flexible, dynamic network which can operate in vacuum and a high-radiation environment with a signal bandwidth exceeding 1 GHz. This project investigates several optical fiber network concepts, ranging from point-to-point signal distribution networks and processor bus extenders implemented with optical fibers to a fiber-bus network using an all-optical crossbar switch as the center hub interconnecting many processors and devices. The crossbar switch is capable of 5 microsecond reconfiguration time, wide bandwidth (>1 GHz), and the transmission of either analog or digital data. The Phase I study will consider network architectures, multiplexing hardware and formats, protocols, switching and reconfiguration requirements, and interfacing to sensors and signal processing devices in present and future spacecraft and space platforms.

Potential Commercial Applications: Optical fiber networks could be applied in military aircraft for fusion of imaging radar, tracking, sensor data; in medical image data collection and distribution; and for local and wide-area networks for image processing.

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108
88-1-07.06-0040
An Interactive Algorithm Design Tool for Embedded Multiprocessor Systems
Advanced System Technologies
5113 Leesburg Pike, Suite 514
Falls Church, VA 22041
Duane R. Ball (703-845-0040)
LaRC -- NAS1-18809

This project addresses an interactive algorithm design tool for embedded multiprocessor systems. Designers will specify algorithm structure as a directed graph of interconnected nodes. The tool automatically partitions these graphs into tasks and then assigns these tasks to processors in an optimal manner based on the target multiprocessor system characteristics. The optimized tasks will be translated into an Ada template to support algorithm implementation on a target multiprocessor system. The innovation in this project is the unique combination and integration of graphics, optimization, algorithm evaluation, and code generation technologies which decouple algorithm functionality and computational complexity issues from implementation level performance decisions. By automating much of the design process, producing optimal graphs, and ensuring that the code is traceable to the design, the software development process will be less costly, more timely, and more reliable. In order to show technical feasibility, this project has three technical objectives which are: to develop a graphical algorithm specification language, to devise a technique to generate target optimal implementations of parallel algorithms, and to design an automatic technique to translate optimized graphs into Ada code templates.

Potential Commercial Applications: Principal beneficiaries of this work will be agencies and industries which have requirements for high performance, fault tolerant, embedded systems.

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109
88-1-07.06-0540
Magnetic Spindle Bearing for an Optical-Disk Buffer
SatCon Technology Corp.
71 Rogers Street
Cambridge, MA 02142
Richard L. Hockney (617-661-8942)
LaRC -- NAS1-18822

The advent of optical-disk recording technology has made possible a family of high-data-rate, high-capability memory devices. Bearings are an enabling technology area; that is, improvements are required to allow these systems to be utilized in space applications. Air bearings, utilized in ground-based systems, are impractical in space. Experience with rolling element bearings has been limited and unsatisfactory. With proper development, magnetic bearings represent an ideal candidate for the rotating spindle of these devices. They combine low noise, excellent positioning accuracy, with zero wear and no lubrication requirement. The project will examine the feasibility of developing magnetic bearings for the spindle of a high-performance, optical-disk buffer. The effort will include definition of the magnetic bearing specifications, design of the actuator configuration, determination of the controller characteristics, design of the position sensor, and definition of the electronic circuitry requirements.

Potential Commercial Applications: This technology could pertain to a wide range of high-performance commercial applications including optical-disk buffers.

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110
88-1-07.09-3221
Intelligent Information Management with Xy Imaging
Spectrum Management Group Inc.
12500 San Pedro Avenue, #445
San Antonio, TX 78216

Michael R. Thomas (512-496-3221)
JPL -- NAS7-1049

This project has the purpose of developing an innovative data structure that has the ability to capture, store, and retrieve information based on its semantic content. This should be possible through the use of a newly developed technique called "Xy-imaging". Based on mathematical transforms, this technique captures the content of information items in a multidimensional, phase-space image. In contrast, existing data structures allow only for the storage and retrieval of data based on the address of the data. The innovation considered in this project allows users to store information by providing data in any format and retrieving it in the same fashion, that is, without knowing the address of the data. With such a capability as this, textual and graphical data can be stored and manipulated from individual systems or a broad network of data bases and computers into meaningful information units. In addition, by its nature, this technique can provide an extremely user-friendly and intuitive man-machine interface.

Potential Commercial Applications: This project could lead to a new class of software products for addressing multimedia information based on semantic meaning rather than a string of characters.

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* 111
88-1-07.10-4651
An Extensible Shell for Information Access in Heterogeneous Environments
HSA Inc.
3806 Springhill Lane
Sugar Land, TX 77479
Poonam Salona (713-980-4651)
GSFC -- NAS5-30483

The innovation described here is the development of a software tool, InfoShell, that addresses the problem of assisting users to locate and access multimedia information resident in heterogeneous, distributed environments. InfoShell embodies a novel approach which merges the state-of-the-art in user interface technology with proven concepts of the library paradigm to provide an icon-driven, integrated, extensible, user-friendly, and portable front-end for information access.

In Phase I, a detailed design of the InfoShell software will be developed. The applicability and merit of the software tool will be demonstrated by developing a prototype. The thrust of Phase II will be the implementation of the InfoShell design developed in Phase I and its integration with NASA's Distributed Access View Integrated Database (DAVID) system.

Potential Commercial Applications: InfoShell could become a necessity for dissemination of large amounts of information or information fragmented in heterogeneous distributed environments to a diverse user community.

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08 INSTRUMENTATION AND SENSORS

* 112
88-1-08.01-0888
Heterostructure Infrared Detectors for Use at Wavelengths Longer than 14 Microns
Microtonics Associates Inc.
4516 Henry Street, Suite 403
Pittsburgh, PA 15213-3728
Darryl D. Coon (412-681-0888)
JPL -- NAS7-1051

Heterostructure, infrared detectors (super-lattice devices operating in the photovoltaic mode) are proposed for use at wavelengths greater than 14 microns and operating temperatures between 40 K and 80 K. Since these detectors rely on intraband transitions, they can use wide-band-gap materials which pose fewer problems than intrinsic, narrow-band-gap materials such as HgCdTe. The heterostructure approach permits the parameters controlling detector response and operating temperature to be continuously adjusted and optimized in a way which is not possible with extrinsic detectors.

Phase I will model and calculate responsivity, dark current, noise, and detectivity as functions of the heterostructure device parameters. Trade-offs between operating temperature and useful detector response will be analyzed. In Phase II, prototype AlGaAs/GaAs devices and arrays will be fabricated using molecular-beam epitaxy and then tested. Test data will be compared with the results of Phase I analyses.

Potential Commercial Applications: A Phase II subcontract with the Westinghouse Company could facilitate the use of the products of this project into imaging and image processing systems.

***

113
88-1-08.01-1188
High-Gain Avalanche Photodiode Arrays for Long-Wavelength Applications
Epitaxx Inc.
3490 US Route One
Princeton, NJ 08540
Gregory H. Olsen (609-452-1188)
JPL -- NAS7-1043

This project aims to develop high-performance arrays of indium-gallium-arsenide (InGaAs) avalanche photodiodes (APDs) for fiber-optic remote sensing and spectroscopy in the 1.0 -1.7 micron spectral band. Its goal is to increase array sensitivity a factor of ten over conventional pin detectors. The innovation combines a novel doping and thickness profiling technique with modifications to the vapor-phase epitaxy, crystal-growth system to provide unprecedented uniformity in thickness and doping, two parameters which dramatically affect APD performance. The APD structure chosen is a simple, planar, floating guard-ring structure recently demonstrated by the company to operate at room temperature.

In Phase I, InP/InGaAs layers will be grown and their doping-thickness profiles measured by non-destructive means. The plan is to fabricate 60 μm diameter APD devices and correlate the profiles with yield. Plans for Phase II include development of a ten-element linear APD array with associated read-out schemes and control circuits having a gain of ten and a NEP (noise equivalent power) below 10^{-13} Watts per Hertz at room temperature.

Potential Commercial Applications: Applications include astronomy, remote sensing, satellite imaging, spectroscopy, and photoluminescence.

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*** 114**
88-1-08.01-7074
Silicon Bolometer Arrays for Helium-3 Detector System
Infrared Laboratories Inc.
1808 E. 17th Street
Tucson, AZ 85719
W. M. Poteet (602-622-7074)
JPL -- NAS7-1039

This project investigates the feasibility of fabricating building blocks for large-scale, cryogenic, infrared, bolometer arrays for remote sensing for planetary exploration and Earth observations. Silicon bolometer arrays offer the possibility of substantial improvements in performance over other IR detectors for many background levels in the wavelength range of 2.5 to 500 micrometers. Successful operation, however, requires that each pixel be thermally isolated. The approach will be to develop techniques for fabricating modular, linear arrays of eight detectors which can then be stacked to form eight-by-eight arrays or joined into linear arrays of 64 or more detectors. Multiplexers and cold amplifiers for array read-out as well as warm electronics will be designed. Feasibility demonstration testing will use the eight-element bolometer array.

Potential Commercial Applications: Applications could include sensing in the thermal-infrared region for chemical spectroscopy and medical imaging.

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*** 115**
88-1-08.02-1020
Improved Cavity Radiometer for Radiance Measurements
The Eppley Laboratory Inc.
12 Sheffield Avenue
Newport, RI 02840
John R. Hickey (401-847-1020)
GSFC -- NAS5-30597

This project seeks improvement of self-calibrating, thermopile-based, cavity radiometers for use in radiance measurements from Earth-viewing satellite instruments. The primary thrust is to improve the response of the device and minimize possible thermal offset signals within the sensor. The approach involves redesign of the thermal impedance of the thermopile element and optimization of the plating technique for the junctions. In addition, the effects of reducing the thermal transients in the heat sink and the baffle-aperture assembly to a minimum will be studied. The design will consider allowing the sensors to be employed in a contiguous array for use in a non-scanning Earth radiance instrument.

Potential Commercial Applications: A self-calibrating radiation detector for the infrared and visible regions could complement the firm's present line of precision radiation instruments supplied to worldwide markets.

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*** 116**
88-1-08.02-1982
Rain-Rate Instrument for Deployment at Sea
FWG Associates Inc.
217 Lakewood Drive
Tullahoma, TN 37388
Shad Arman (615-455-1982)
MSFC -- NAS8-38040

Effective prediction of global phenomena requires detailed knowledge of temperatures, rainfall rates, and particle size distributions. To gain an understanding of the effects of tropical latent heating on global atmospheric circulation, satellite measurements of tropical precipitation patterns have been proposed using sensitive, sophisticated, infrared and microwave systems. To obtain surface truth data at sea, instruments must be flown aloft in order to reduce ship interference, sea spray contamination of data, etc. No single commercially available device can meet all the needs for at-sea rainfall measurements. The innovation is to monitor particle sizes through the use of multiple instruments such that the merging of data from the instruments is statistically tractable. This project will investigate an optical sizing technique, fiber-optics data transfer, and data reduction algorithms which can be combined into a highly portable instrument for measuring a broad, particle-size spectrum and rainfall rates while carried aloft by a remote, tethered vehicle.

Potential Commercial Applications: Applications could occur in testing aircraft for meteorological effects.

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*** 117**
88-1-08.02-2299
Diode-Pumped Laser Altimeter
Schwartz Electro-Optics
45 Winthrop Street
Concord, MA 01742
Peter F. Moulton (508-371-2299)
GSFC -- NAS5-30482

Diode-pumped, solid-state lasers are compact, relatively efficient, long-lifetime sources of coherent radiation and are well-suited to a number of NASA space-based, active remote-sensing systems. This innovation combines the use of a diode-array-pumped neodymium (Nd) laser with pulse-transmission-mode, Q-switching to generate the one-nanosecond-duration

pulses required for one particular sensing application, high-precision laser altimetry. This combination has, to our knowledge, not yet been implemented in diode-pumped lasers but is more favorable for nanosecond pulse generation than more conventional Q-switching techniques. Also, the overall efficiency of transverse-pumped, single-transverse-mode Nd lasers will be improved over current levels by the use of innovative pumping and laser-cavity geometries. Improvements in efficiency and consequent reduction in both electrical power consumption and heat generation are of major importance in space-based systems and other remote-sensing applications.

Potential Commercial Applications: Uses could occur in high-reliability, compact optical range-finders exhibiting long lifetime and high range-resolution.

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118
88-1-08.02-6070
A Compact Optical Rain Droplet Distrometer for Unattended Field Operation
Scientific Technology Inc.
2 Research Place
Rockville, MD 20850
Ting-I Wang (301-948-6070)
GSFC -- NAS5-30484

Data on precipitation parameters are critically needed for global-scale climate monitoring. The major source of data will be estimates of rainfall amount derived from geostationary satellite observations. Since these are indirect measurements, validation through ground-based measurements is required. This project concerns development of an instrument for in-situ measurements of instantaneous droplet size distributions and rain rates using optical scintillations. The instrument will be compact and permit unattended weather observations.

In Phase I, the firm will conduct a theoretical and empirical study to obtain the optimum design parameters for a prototype sensor. The design will address the important engineering and operational issues and will contain sufficient detail to make an assessment of the resources required for Phase II development.

Potential Commercial Applications: A compact instrument for unattended field operation could have domestic and international commercial applications for obtaining rain data.

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*** 119**
88-1-08.03-0204
Multi-Spectral High Resolution Remote Sensor
SSG Inc.
150 Bear Hill Road
Waltham, MA 02154
Harold A. Graham (617-890-0204)
SSC -- NAS13-385

This Phase I project will study the requirements, conceptual design, and cost trade-offs and then demonstrate optics feasibility for a multi-spectral, high-resolution, low-cost remote sensor capable of a real-time display. In order to achieve a low cost design, the sensor uses production components. The optics system is a high-quality, all-reflective system to provide broad wavelength coverage and high resolution. It uses multi-element arrays of cryogenically cooled IR detectors for high sensitivity and high speed response. The system will be sized for a variety of platforms, *e.g.*, light aircraft or balloons. Optical performance will be demonstrated by a breadboard. The output of the sensor will be calibrated on a frame by frame basis by reference to a blackbody emitter.

Potential Commercial Applications: The product could be applied for pollution monitoring, energy conservation, oceanography, and mineral exploration.

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*** 120**
88-1-08.04-2260
Improved Pulsed-Discharge TE Laser
QSource, Inc.
151 Deercliff Road
Avon, CT 06001
Peter P. Chenausky (203-677-2206)
MSFC -- NAS8-38033

A sensor system such as NASA's LAWS system could be improved if CO_2 laser transmitters could provide the required pulse widths and output energies. The innovation simplifies a pulsed, transverse electric (TE) discharge, CO_2 laser transmitter by eliminating pre-ionization electrodes and the high-power switch in the main discharge circuit. These features allow for arc-free operation up to pulse-repetition-frequencies of several hundred Hertz in a completely sealed, non-recirculating, non-catalyzed medium. Phase I will extend testing of an existing laser having an active medium of 1x1x17 cc to a pressure of 375 torr, an input energy of 0.25 joule, and an output efficiency of 10 percent. Phase II would extend testing to another existing TE laser (1.5x1.5x155 cc active-medium) to 3.8 joules per pulse, 15 percent efficiency, and sealed, non-recirculating repetition rate of 10 Hz. A future version could contain fewer than six intra-vacuum components, and have an operating lifetime of years.

Potential Commercial Applications: The innovation could apply to all pulsed, TE discharge lasers for use in marking, scribing, cutting, medicine, remote sensing, and numerous scientific applications.

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*** 121**
88-1-08.05-7670
Auto-Aligned Fourier Transform Ultraviolet Spectrometer
Optra Inc.
66 Cherry Hill Drive
Beverly, MA 01915
Geert Wyntjes (508-535-7670)
JPL -- NAS7-1060

The purpose of this project is the demonstration of a technique to stabilize actively the optical alignment of a Michelson interferometer spectrometer for operation in the ultraviolet region. The technique involves the application of a metrology system based upon a two-frequency laser to measure and generate feedback signals for active control of the interferometer mirror. The project will proceed in two phases. The first phase involves the demonstration of the ability of the proposed technique to maintain interferometer alignment for path lengths consistent with 0.25 wavenumber resolution at 300 nanometers using the commercially available OPTRALITE two-frequency laser develop by the firm. The second phase would replace the two-frequency gas laser with a chirped diode laser to provide essentially the same reference signals that are available with the gas laser.

Potential Commercial Applications: The robust, inexpensive device that may result from this project could be deployed in the field for scientific investigations and in commercial applications of spectrometry.

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* **122**
88-1-08.06-3409
Short Wavelength AlGaAs Diode Lasers
Northeast Semiconductor Inc.
95 Brown Road, #141
Ithaca, NY 14850
Colin E. C. Wood (607-257-8827)
GSFC -- NAS5-30493

This project investigates the fabrication of efficient, semiconductor, diode lasers which operate at wavelengths from 680 nm to 790 nm. These lasers will be constructed from AlGaAs quantum wells grown by molecular-beam epitaxy (MBE). A special 850-nm, quantum-well-laser, superlattice structure developed by this company for growth by MBE will be adapted for shorter wavelength operation. Also, new structures will be developed for laser wavelengths as short as 680 nm. The laser structures will be optimized to obtain low-threshold, high-efficiency operation. Attention will be given to reproducibility of specific wavelengths within the above wavelength range.

Potential Commercial Applications: Diode lasers in the 680 - 790 nm range could be employed in a wide range of consumer products including high density optical disks, laser printers, and bar code readers.

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* **123**
88-1-08.07-0755
Tunable, Single-Frequency, Solid-State Laser Transmitter
Lightwave Electronics Corp.
1161 San Antonio Road
Mountain View, CA 94043
Richard W. Wallace (415-962-0755)
LaRC -- NAS1-18827

The recent demonstration at Stanford University of nonlinear conversion efficiencies greater than 50 percent using a continuous-wave (CW), single-frequency laser encourages a fresh look at optical parametric oscillators. Two key breakthroughs contributed to these significant results: the development of a single-frequency, diode-pumped, solid-state laser and the development of nonlinear crystals having very good optical quality. The single-frequency laser and the low-loss crystal make it straightforward to use the technique of external resonant enhancement to obtain high conversion efficiencies even at very low CW power levels. The innovation is to apply these external, resonant-enhancement techniques in an all-solid-state, single-frequency, tunable laser source.

Potential Commercial Applications: Applications range from LIDAR and spectroscopy studies to color-multiplexed, high-capacity communication systems.

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124
88-1-08.07-6000
2.1 Micrometer LIDAR Detector
Spire Corporation
Patriots Park
Bedford, MA 01730
Kurt J. Linden (617-275-6000)
LaRC -- NAS1-18828

This project addresses a photovoltaic LIDAR detector with a spectral response peak in the 2.1 μm spectral region needed to match the emission from high performance Ho:YAG solid-state lasers. Two semiconductor materials are promising for yielding high performance 2.1 μm photovoltaic detectors: HgCdTe and InGaAs. The former material is extremely difficult to work with and very expensive. The latter is metallurgically better behaved, is in wide use in the 1.3 and 1.55 μm spectral regions, and can be made to have a spectral response peak at 2.1 μm.

InGaAs, prepared in one step by the metallo-organic CVD growth process, holds the promise of leading to low-cost, high performance photodiodes with a 2.1 μm spectral peak. The proposed work is compatible with present, in-house programs for growing InP-based materials.

Potential Commercial Applications: LIDARs that could be carried on aircraft would allow real-time monitoring of atmospheric turbulence, wind-shear, and micro-bursts over the three-mile range required to assure safe landings. The market for such systems numbers tens of thousands, worldwide.

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125
88-1-08.07-7067D
SIS Detector in the 100-Micron-Wavelength Region Fabricated with a Thin Film Superconductor
Excel Technology Inc.
140-20 Keyland Court
Bohemia, NY 11716

Rama Rao (516-563-7067)
LaRC -- NAS1-18803

This project examines the feasibility of an SIS detector (Josephson junction) for the 100-micron-wavelength region based on the Bi-Ca-Sr-Cu-O superconductor with a transition temperature of 110 K. The use of this material eliminates the need for rare-earth elements to achieve superconductivity. Bulk samples of BCSCO will be prepared by the solid-state reaction method. Then, superconducting films of 3-5 micron thickness will be deposited on a suitable substrate (MgO) by the laser-induced deposition technique. To form the Josephson junction, a part of the substrate surface will be ground down or etched to form a groove of about 5 microns deep prior to the deposition. Detector responsiveness and minimum detectable power level will be determined using a modulated, black-body source. The responsivity of the proposed SIS detector is estimated to be 10^4 V/W, which is several orders (4-5) of magnitude higher than the presently available detectors. Response time of the detector will be investigated in Phase II.

Potential Commercial Applications: Applications could be in the area of far-infrared spectrometry, astronomy, radiometry, night vision, and communications.

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126
88-1-08.08-5649A
Feasibility of Modifying a Thermal Scanner to Measure Lava Flow Characteristics
Daedalus Enterprises Inc.
PO Box 1869
Ann Arbor, MI 48106
James P. Lehotsky (313-769-5649)
JPL -- NAS7-1054

This project will investigate the modification of the existing thermal infrared multispectral scanner (TIMS) to measure lava flow characteristics. It addresses a critical need for an instrument to make accurate measurements from aircraft of the temperature of the surface of lava flows to support the NASA Geology Program in the study of the composition and dynamics of high-temperature lava flows. The activity involves the analysis of several spectrometer and scan-head modifications which could be implemented using TIMS optical components. In addition, the project will examine the signal processing electronics for changes required to improve the dynamic range of the system. Alternative designs will be evaluated for their compatibility with the existing system. Successful completion of this project will result in an instrument capable of making temperature measurements of hot surfaces with the option of conversion to the standard TIMS configuration with improved dynamic range.

Potential Commercial Applications: The instrument could be used in research and operations dealing with wild fires.

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127
88-1-08.08-6100
Tunable BBO and $AgGaSe_2$ Optical Parametric Oscillator System
Cleveland Crystals Inc.
19306 Redwood Avenue
Cleveland, OH 44110
Gary C. Catella (216-461-1384)
JPL -- NAS7-1061

In order to provide efficient, tunable, broad-band sources of coherent radiation, this project will investigate the feasibility of compact, solid-state optical parametric oscillators (OPOs) using BBO and $AgGaSe_2$ with a common laser pump to cover the wavelength region from 0.19μ to 11μ. A Nd:YAG laser operating at 1.064μ is the best common pump. The fourth harmonic of this line will pump the BBO OPO. A parametrically doubled wave length will serve for the $AgGaSe_2$ OPO. The Phase I effort will determine the basic performance of these OPOs and measure the efficiency of the pump and the three-wave mixing steps necessary in the use of a common laser pump. The generation of short and long wavelength pumping will be optimized, and a system using a common laser pump and dual OPOs will be demonstrated in the laboratory. Overall system efficiency will be calculated and compared with experimental data.

Potential Commercial Applications: Applications could include spectro-photometry, nonlinear spectroscopy, wavelength-selective surgery, materials processing, laser photochemistry, and optical communications.

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128
88-1-08.09-1315
Towable Advanced Bio-Optical Sensor System
Biospherical Instruments Inc.
4901 Morena Blvd., Suite 1003
San Diego, CA 92117
Charles R. Booth (619-270-1315)
JPL -- NAS7-1044

This project addresses the need for cost-effective instrumentation to obtain data at the surface for validation of future ocean-color sensors such as the pending SeaWiFS satellite and planned MODIS and HIRIS high-resolution scanning sensors. The approach couples optical fibers with the technology of high-resolution spectrometers to yield a small optical sensor head that can be deployed in various modes including being towed behind ships. The innovation has two parts: a deployable, passive, optical-fiber collector assembly to bring the signals to a detector on ship-board and a modern array spectrometer with a spectral resolution comparable to the anticipated EOS-based remote sensing systems of the 1990s.

Potential Commercial Applications: This instrument could be applied for global studies, activities related to anti-submarine warfare, and commercial fisheries.

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* 129
88-1-08.10-0507
Ion Mobility Sensing of Extraterrestrial Volatiles from Gas Chromatography
PCP, Inc.
2155 Indian Road
West Palm Beach, FL 33409
R. F. Wernlund (407-683-0507)
ARC -- NAS2-12997

The goal of this project is a miniature, specialized, flight-qualified, ion mobility spectrometer (IMS) to identify and quantify organic volatile effluents from a gas chromatograph (GC) at concentrations of 10^{-14} moles per second.

In Phase I, a combined IMS and quadrapole mass spectrometer will be modeled to determine optimum structural parameters. Alternate ion sources, including alpha and beta emitters, ultraviolet lamps, and corona discharge will be considered. A demonstration of an IMS feasibility model using a laboratory GC will be made. The Phase I report will contain preliminary design recommendations for the flight-qualified IMS sensor. In Phase II, the IMS design will be perfected for optimum performance, a prototype built and tested, and a few units delivered. Concurrently, a data base will be prepared for selected gas chemistry and pertinent volatile compounds.

Potential Commercial Applications: Products of this work could be a pocket-sized, personal IMS sensor of toxic organic volatiles and, in combination with a portable GC, a monitor for environmental and industrial volatile matter.

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* 130
88-1-08.11-5435A
AOTF Enhancements for Space-Based Spectro-Polarimeter
AOTF Technology Inc.
540 Weddell Drive, Suite 6
Sunnyvale, CA 94089
Patrick Katzka (408-734-5435)
JPL -- NAS7-1052

The objective of this program is to develop technology for a space-borne imaging spectropolarimeter utilizing acoustic-optic tunable filters (AOTFs). The major significant innovation of this proposed program is to develop an observational scheme to return high quality I, Q and U Stokes parameters utilizing the performance advantages of AOTFs.

Specific innovations include: extended AOTF spectral coverage with a minimum of devices; development of innovative transducer and/or AOTF designs to provide flexible choices of passband shape and positions; and the use of new materials to develop AOTFs and polarizers capable of efficient operation to 2000 angstroms, where performance has limited the development of AOTF-specific optical designs. In addition to device innovations, novel data reduction and compression techniques will be addressed.

Potential Commercial Applications: Uses could occur in geological, oceanographic, and agricultural fields and for survey of resources.

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131
88-1-08.12-1856
Joule-Thomson Cryo-Refrigerator for Spacecraft Sensors and Stored Cryogens
General Pneumatics Corporation
7662 E. Gray Road, Suite 107
Scottsdale, AZ 85260
Ernest E. Atkins (602-998-1856)
ARC -- NAS2-12990

A long-life, high-reliability helium liquefier for providing cryogenic refrigeration to spaceborne instrumentation and cryogenic storage dewars will be developed. The proposed cryo-refrigerator is a triple-fluid, cascaded Joule-Thomson (J-T) system which uses argon, neon, and helium as the working fluids. The system incorporates major innovations in sealed, high-pressure compressor design, non-clogging, temperature-regulated J-T cryostats, an intermediate valveless expander to increase liquefaction yield, and the use of neon to avoid the safety problems of hydrogen use. The component improvements derived will be generally applicable to other J-T cryo-refrigeration systems.

Potential Commercial Applications: The subject cryocooler could be applied in numerous research, medical, and commercial applications such as infrared sensors, magnetic resonance imagers, superconductors, and materials research. It would also make possible practical, safe, on-site helium reliquefaction.

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* 132
88-1-08.12-3800
A Thermally Effective Regenerator for Low-Temperature Cryocoolers
Creare Inc.
PO Box 71
Hanover, NH 03755
W. Dodd Stacy (603-643-3800)
JPL -- NAS7-1041

Small Stirling cryocoolers are limited in the attainment of very low temperatures by the adverse trend in the ratio of volumetric heat capacity between gaseous helium and regenerator matrix materials below about 40 K. The proposed concept for a thermally effective regenerator overcomes this limitation by providing a dynamic helium matrix. The objective of the Phase I project is to demonstrate experimentally the relative thermal storage effectiveness of this regenerator configuration and a more conventional regenerator between 4.2 K and 77 K. The effort includes design, fabrication and testing of an innovative regenerator over a range of mass flows, pressures, and operating frequencies.

Potential Commercial Applications: Small Stirling cryocoolers (2-4 K temperature) could support the operation of various superconducting devices useful in communication, medicine, laboratory research, and small-scale condensing of helium for laboratory use.

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* 133
88-1-08.12-5925
GaAs Analog Preprocessing Electronics for Infrared Astronomical Applications
Top-Vu Technology
2650 14th Street N.W.
New Brighton, MN 55112
Ngoc-Chi N. Vu (612-633-5952)
ARC -- NAS2-12987

Gallium arsenide analog preprocessing electronics (GAPE) are proposed for spaceborne infrared astronomical telescope projects. Linear GaAs integrated circuits will be used for detector readout and signal conditioning/processing in order to provide reliable operation at cryogenic temperatures with regard to freeze-out and radiation hardness. The success of the GAPE concept will improve the performance of spaceborne IR telescopes at cryogenic temperatures.

Potential Commercial Applications: A chip-based GAPE system could serve in high-performance infrared data acquisition systems and high-speed signal processors in the industry.

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* 134
88-1-08.13-2681
Composite High T_c Superconducting Bolometer
Advanced Technology Materials Inc.
520-B Danbury Road
New Milford, CT 06776
Charles P. Beetz, Jr. (203-355-2681)
GSFC -- NAS5-30598

Present detector technology for the submillimeter wave region consists of low-sensitivity, room-temperature detectors and high-sensitivity, low-temperature detectors. While the latter detectors have low noise, they are inconvenient to use because they operate at temperatures less than 1.5 K. The use of high-T_c, superconducting thin films and low-thermal-mass, low-refractive-index diamond films now makes it possible to construct a composite bolometer operating in the temperature range 95-125 K with a potential NEP of about 10^{-13} W/$Hz^{1/2}$. The purpose of Phase I is to demonstrate that high-T_c, superconducting thin films can be deposited on diamond films and that a narrow superconducting transition can be obtained. Phase II will develop a prototype composite bolometer for evaluation as a submillimeter wave detector.

Potential Commercial Applications: The project could lead to the commercialization of high temperature superconducting bolometer infrared detectors.

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* 135
88-1-08.13-3666
Cryogenically-Cooled InSb JFET
Electro-Optek Corporation
3152 Kashiwa Street
Torrance, CA 90505
William S. Chan (213-534-3666)
GSFC -- NAS5-30496

Many microelectronic circuits used in high-performance infrared systems are required to operate at cryogenic temperatures and be low noise at the same time. For these applications, this project investigates a new and innovative technology for InSb junction-field-effect transistor (JFET) devices and circuits. It is based on molecular beam epitaxy (MBE) of InSb layers on InSb and sapphire substrates. The n- and p-layers can be made by in-situ doping; thus, the JFET structure can be fabricated readily by MBE. The resultant InSb JFET devices can be operated at a temperature below 2 K and are capable of extremely low noise (under a nanovolt per $Hz^{1/2}$), two highly desirable characteristics for electronics for infrared (IR) sensors in the long wavelength IR (LWIR) spectral region. The aim of Phase I is to establish the low-temperature model for InSb JFETs and to define the MBE processes and requirements to fabricate the multiple layer structure.

Potential Commercial Applications: Applications could arise in low-noise microcircuits for high-density and high-speed microelectronics.

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136
88-1-08.13-5411
Manufacturing Large-Area, High-Gain Microchannel Plates
Detector Technology Inc.
PO Box K-300
Brookfield, MA 01506
Thomas J. Loretz (508-867-5411)
GSFC -- NAS5-30456

A prototype of a revolutionary new instrument design has been developed as a manufacturing means for both large- and small-format, high-gain microchannel plates (MCPs). The method used for manufacture has been called the shear method. Considerable research is needed to address the many parameters which govern the successful application of this instrument to the task of fabricating a "sheared" MCP blank. This project will test and evaluate all aspects of the instrument design theory for 25 mm and 40 mm wafer shears and provide the foundation for future research into 75 mm plates.

Potential Commercial Applications: A variety of applications could exist in the fields of particle physics, space physics, analytical chemistry, and nuclear chemistry.

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* 137
88-1-08.13-7670
Fiber Optic Loop Antenna for the Measurement of Electric Currents in Space
Optra Inc.
66 Cherry Hill Drive
Peabody, MA 01915
Geert Wyntjes (508-535-7670)
GSFC -- NAS5-30499

A technique to measure electric currents in space based upon sensing of the circular birefringence induced by a magnetic field in a single-mode optical fiber is the goal of this project. A low-loss, single-mode optical fiber in a closed loop is an antenna with a high degree of immunity to stray magnetic fields. Sensitivity is further enhanced through use of a coherent, heterodyne optical receiver based on the two-frequency HeNe laser developed by the firm. In addition, the use of a complex, homodyne receiver with a low-power diode laser as a source will be explored. Both of these techniques allow for a large signal bandwidth with the final, post-detection bandwidth limited only by the averaging time constant chosen. The low weight and stowage volume of the antenna suit it to deployment from manned and unmanned space craft. While the technique will only be demonstrated for a single axis, the concept can be readily expanded to measure vectors.

Potential Commercial Applications: The results this project could be applied to the measurement of displacement currents near power lines and in the study of lightning.

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138
88-1-08.14-7972
Reversible Oxide Chemical Compressor for Sensor Cryocooling
Hydrogen Consultants Inc.
12420 N. Dumont Way
Littleton, CO 80125
John R. Riter (303-791-7972)
JPL -- NAS7-1047

A vibration-free, long-lived refrigerator is desired to produce cooling for spacecraft sensors in the 65-80 K range. A chemical oxygen compressor and Joule-Thomson expansion combine to form an appealing way to provide such cooling, but chemical compressors are limited by a low oxygen content of current materials, *e.g.*, PrCdO with 1.5 weight-percent of oxygen. The goal of this project is to formulate long-life materials with the correct physical and chemical properties to compress oxygen. A large surface area for both the unoxidized and oxidized materials is the critical physical property; whereas, the most important chemical property is good reversibility of the oxidation process. The chief improvements expected are an order of magnitude increase in the weight-percent of oxygen over PrCdO and a lower maximum operating temperature. Phase I will investigate of the sorption thermodynamics and kinetics of candidate oxygen storage materials to determine their operating parameters. Construction and testing of a working oxygen compressor would occur in Phase II.

Potential Commercial Applications: Safe, high density solid state oxygen storage materials and sorption refrigeration devices could have both terrestrial and aerospace applications.

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139
88-1-08.15-2719
Ultrasonic Transducers: Deployment and Signal Processing Means for Cryogens
Panametrics Inc.
221 Crescent Street
Waltham, MA 02254
Lawrence C. Lynnworth (617-899-2719)
LeRC -- NAS3-25371

Ultrasonic instrumentation for cryogenic fluid aboard orbiting spacecraft faces problems in at least three areas: transducers must withstand temperatures as low as 20 K; location of transducers must be minimally-invasive and permit measurement of desired parameters; and the signal processor must compute flow parameters while neglecting noise. In Phase I, analysis and experiments will concentrate on the first two problems. To solve the thermal problems, novel, slender transducers will be constructed using materials of nearly matched expansion coefficients and with point-contact coupling. Novel deployment includes acoustically-isolated, point-source flowmeter transducers and a modified H_2-slush density sensor of 1x3 mm cross section for mass gauging and mass-flow metering. A commercial unit will be applied in processing signals for feasibility demonstrations in water and in cryogens. A method of reducing coherent noise will be investigated which could improve the accuracy of non-invasive ultrasonic measurements by a factor of ten.

Potential Commercial Applications: A need exists for a non-invasive flowmeter for low-density hydrocarbon fluids, some gases (including steam), and two-phase fluids at temperature extremes or in a malevolent environment.

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140
88-1-08.16-8181
Wideband Acousto-Optic Spectrometer
Photonic Systems Inc.
1900 S. Harbor City Blvd.
Melbourne, FL 32901
Dennis R. Pape (407-984-8181)
JPL -- NAS7-1048

An acousto-optic spectrometer for spaceborne astronomical and scientific applications will be developed. In addition to meeting environmental and lifetime requirements, it will be highly stable and have a 1 GHz bandwidth, 1 MHz resolution, and 50 dB

dynamic range packaged. Current developments of wideband, acousto-optic spectrometers for airborne electronic warfare applications involving short-pulse detection cannot meet these requirements. The approach of this project utilizes a laser diode, an innovative wideband Bragg cell design, and a high-dynamic-range, self-scanned, integrating photodetector array all assembled in a mechanically and thermally stabilized package to meet the stability and environmental requirements of spaceborne applications. Phase I will include the development of the spectrometer design, including component analysis and selection, Bragg cell design, and optical and mechanical design and analysis.

Potential Commercial Applications: A low-cost wideband parallel spectrometer could find a market in the evaluation of electromagnetic emissions from electronic equipment.

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*** 141**
88-1-08.17-1520
Technique to Evaluate UV-Induced Degradation of Space Optics
Deacon Research
900 Welch Road, Suite 203
Palo Alto, CA 94304
Mira H. Bakshi (415-326-1520)
GSFC -- NAS5-30457

Contamination of optical surfaces in space reduces their performance and occurs as a result of UV-induced photolysis of organic molecules from the spacecraft's contamination cloud. However, more must be known about the chemistry of this process to counteract it by avoiding certain materials or by removing the accumulated material. To provide increased understanding, chemistry of the contamination process will be simulated at a synchrotron radiation facility in an existing surface analysis chamber. The capability will be added for detecting neutral fragments which emerge from the photon-induced reaction, and reaction channels for the photochemical processes will be determined. This will identify the molecular subgroups which are the principal cause of the contamination of space optics.

Phase I will address the feasibility of this approach by analyzing the alternative methods for ionization and detection of the neutral reaction fragments. Phase II would involve construction of the apparatus; performance of photolysis measurements; and interpretation of the data on the complex lubricant and solvent molecules and their isolated subgroups.

Potential Commercial Applications: A service to the space industry could develop for materials testing in relation to the contamination of optical surfaces.

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142
88-1-08.17-7885
Three-Axis, All-Rotary-Motion, Numerically Controlled Optical Component Generator
Breault Research Organization Inc.
4601 E. First Street
Tucson, AZ 85711
Robert Parks (602-795-7885)
GSFC -- NAS5-30498

An innovative, low-cost, 3-axis, numerically-controlled optical generator suitable for use in grinding glass or ceramic parts as well as for machining metals to optical tolerances will be developed. This design uses rotary bearings on all three axes to achieve high accuracy and low cost. It will have the capacity to generate either rotationally symmetric or asymmetric optical components 12" in diameter with a sagittal focus of up to 1". However, the design concept should permit generation of components of either larger diameter or a deeper sagittal focus. To keep cost low, the generator will use commercial components including a PC-based control system. To obtain surface finishes suitable for direct optical polishing, a dynamic tool balancing and dressing station will be built into the instrument.

The Phase I effort will layout the overall generator, identify suitable components, and predict the instrument's performance. Also, the Phase II prototype fabrication cost and Phase III commercial instrument costs will be estimated.

Potential Commercial Applications: This device could prepare ceramic molds for replication of aspheric glass components and generation of exotic surface figures in virtually any material (glass, tungsten carbide, silicon, silicon carbide, stainless steel).

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*** 143**
88-1-08.18-0700
Digital Image Profilers for Detecting Faint Sources Which Have Bright Companions
Laser Power Corporation
12777 High Bluff Drive
San Diego, CA 92130
Graham Flint (619-755-0700)
JPL -- NAS7-1040

An image processing system capable of detecting extremely faint optical sources located in close proximity to bright companion sources will be developed. When used with a space-based, one-meter telescope, the system should permit the detection of 14th, 17th, and 18th magnitude stellar objects having angular displacements from a 4th magnitude object of 0.05, 0.25, and 0.5 arc seconds, respectively. Novel features are that it does not require extraordinary measures to be taken to minimize diffraction and scatter of the optical elements or detectors possessing either extreme uniformity in sensitivity or extreme temporal stability. Furthermore, the system can readily be calibrated by testing against an unresolved singular stellar source, and the performance of the system should approach the theoretical limit of photon statistics.

Phase I includes the design, construction, and testing of a single channel breadboard image profiler.

It also includes the analysis and preliminary design of a multichannel, brassboard system to be constructed during Phase II.

Potential Commercial Applications: A specialized commercial market could be in the detection of faint optical sources via ground based telescopes.

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144
88-1-08.19-5094
Innovative Shear Layer Control Methods for Large-Scale Airborne Telescopes
Rose Engineering & Research Inc.
PO Box 5146
Incline Village, NV 89450
William C. Rose (702-831-5094)
ARC -- NAS2-13034

The overall goal of this project is to determine the effectiveness of the cavity resonance suppression characteristics of the forward fairing and ramp combination on the Kuiper Airborne Observatory (KAO). In addition, the improvement in optical "seeing" characteristics of the flow field over the open cavity will be measured. While the effort is to be conducted during full-scale flight tests on the KAO, it is to be done in a timely manner such that experience learned in the Phase I effort will be available for carry-over into a Phase II effort which will impact the design of the cavity resonance suppression system on the Stratospheric Observatory for Infrared Astronomy (SOFIA).

During Phase I, the design of a novel open cavity anti-resonance technique will be performed using an innovative shear layer control fairing in conjunction with an already-designed, contoured aft ramp system of the KAO. Detailed design and fabrication of the aircraft modifications will be carried out by the government. When the aircraft modifications are installed, the contractor will conduct a full-scale flight experiment.

Potential Commercial Applications: The applications would be on airborne installations for surveillance and astronomical observations.

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*** 145**
88-1-08.22-4770
Trace Atmospheric Carbon Monoxide Sensor
Spectral Sciences Inc.
99 S. Bedford Street, #7
Burlington, MA 01803-5169
Lawrence S. Bernstein (617-273-4770)
MSFC -- NAS8-38048

Carbon monoxide, an odorless, colorless, toxic gas, may be found in closed environments such as the Space Station and long-duration manned spacecraft. This project will build a real-time, trace atmospheric CO sensor with a sensitivity to less than 10 ppm. The major objectives of Phase I are to demonstrate experimentally a novel infrared light source, to build a laboratory breadboard detector, and to develop a preliminary design for a CO gas monitor which would be built and tested in Phase II. This innovative CO emission light source can significantly increase the sensitivity of CO gas absorption measurements over the use of more conventional black body infrared source technology. In addition, use of this source would result in an instrument which is compact, responds in real-time, is species-selective for CO gas, and consumes little power.

Potential Commercial Applications: This monitor could be useful for industrial applications such as combustion exhaust and air pollution monitoring and in industries with controlled atmospheres.

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146
88-1-08.23-0204
Diagnostic Contamination Measurement for Space
SSG Inc.
150 Bear Hill Road
Waltham, MA 02154
Andrew A. Mastandrea (617-890-0204)
GSFC -- NAS5-30489

This project addresses the problem of validating relevant spaceborne diagnostic hardware by measuring and quantifying contaminants and their impacts on the performance of a cryogenic, high-stray-light-rejection telescope. Phase I will address the contamination problem on the ground using methods such as internal and external BRDF (bi-directional reflectance distribution function) measurements, and TGA QCM (thermal gravimetric quartz crystal microbalance) analysis and absorption spectroscopy measurements. All of these techniques are applicable to a space environment, which is the goal of a Phase II flight experiment.

Potential Commercial Applications: The research will be used in cryogenic sensors used for atmospheric research, infrared astronomy, and SDIO programs.

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*** 147**
88-1-08.24-9040
Time-Of-Flight Mass-Spectrometer Leak Detectors
Schmidt Instruments
24276 Bolsover, Suite 234
Houston, TX 77005
Howard K. Schmidt (713-529-9040)
LeRC -- NAS3-25372

A novel time-of-flight mass spectrometer (TOF-MS) system for detection of working fluid leaks aboard space craft in flight will be developed. Expected sensitivity of the proposed device is significantly better than that of quadrupole, residual gas analyzers (RGAs). Benefits to NASA would derive from a sensitive and robust detector of working fluid and atmospheric leaks aboard space craft or in large vacuum systems. Extremely simple in construction, these TOF devices will provide high-performance leak detection with compact, reliable, and low-power hardware. Control and data acquisition will be performed by a

small electronics package using designs and custom VLSI components developed by the company specifically for TOF-MS applications. This combination of attributes makes the proposed device reliable enough for stand alone passive leak detection, yet portable enough for actively "sniffing" out leak locations.

Potential Commercial Applications: Applications include general purpose gas analysis for leak detection and process control.

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148
88-1-08.25-7513
Detailed Visualization of Protein Crystal Growth
System Specialists
3125 E. 47th Street
Tucson, AZ 85713
Wade M. Poteet (602-622-7513)
MSFC -- NAS8-38026

This project is developing an instrument for liquid-drop protein crystal growth conducted in both terrestrial and microgravity environments. Visualization and recording of parameters characteristic of growth in high-quality protein crystals is important for biomedical research and processing. A low-cost technique which allows quantitative, non-invasive observation of crystal nucleation, uniformity of growth, and accretion processes will be studied. This optical technique, known as color schlieren, can provide high-quality images of crystals from the onset of nucleation through completed growth, and detailed data are generated which can be modeled for both terrestrial and microgravity environments. One type of color schlieren instrument is currently in use by the investigators for studies involving growth and accretion of chains in biological samples and crystal growth in metal models. Both studies are being carried out in the terrestrial environment as well as in microgravity experiments aboard the NASA KC-135, low-gravity-simulation aircraft

Potential Commercial Applications: Visualization of protein crystal growth is important to biomedical research and processing and development of new drugs.

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09 SPACECRAFT SYSTEMS & SUBSYSTEMS

* **149**
88-1-09.01-1500
Robust Adaptive Control of Large Space Structures
Integrated Systems Inc.
2500 Mission College Blvd.
Santa Clara, CA 95054
Robert L. Kosut (408-980-1500)
LaRC -- NAS1-18818

The stringent performance demands imposed upon large space structures (LSS) in tracking accuracy, response time, and active suppression of structural vibrations require the use of robust, adaptive control based upon on-board system identification. The objective of this project is the development of efficient techniques for system identification and adaptive control which are quite different from the conventional adaptive schemes in that the identification process provides information about modeling uncertainty in the format that is anticipated by the robust control design rule. With such an estimate in hand, the controller can be redesigned to provide robustness with respect to model uncertainty.

The study will address the feasibility of performing on-board plant uncertainty estimation and robust control design by using on-line input-output data. On-board uncertainty estimation and on-board robust control design methods will be studied. The proposed adaptive scheme will be tested on a simulation model of a representative LSS system.

Potential Commercial Applications: Commercial and government applications would involve control systems for use in aerospace.

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* **150**
88-1-09.03-2567A
Development of a Compact, Six-Degree-of-Freedom, Force-Reflecting Hand Controller
Charles Systems Corp.
820 Heatherway
Ann Arbor, MI 48104
Charles J. Jacobus (313-668-2567)
JSC -- NAS9-18094

Tele-autonomous control of manipulators presupposes some type of physically actuated controller at the human interface. This project addresses the design and fabrication of a prototype six-degree-of-freedom, Cartesian-coordinate, hand controller. The device is an X-Y-Z stage to which a three-roll wrist and handgrip is affixed. The six degrees of freedom are measured and communicated to the servo electronics of the manipulator. To aid the operator in achieving tele-presence, the device will provide force reflection appropriately scaled and with a small time delay. An inverse-dynamics, robot control methodology will be employed in the hand controller to resolve the hand controller's actuating torques and forces such that the resultant force and torque at the operator's hand is a scaled version of those required to put the manipulator through the desired movements regardless of manipulator pose and load inertia.

Potential Commercial Applications: Applications could arise in underwater activities and manipulation of objects in hazardous nuclear, biological, chemical environments.

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151
88-1-09.03-8933
Multicolor Flat-Panel Display using Tunable Bi-Refringence Filters
Displaytech Inc.
220 Central Avenue
Boulder, CO 80301
Mark A. Handschy (303-449-8933)
JSC -- NAS9-18091

A multicolor, flat-panel, information display will be developed by combining a monochrome, high-information-content panel with an electrically tunable color filter. Multicolor images are provided by sequentially presenting monochrome images in the three primary colors while simultaneously tuning the filter for the correct illumination color. The novel tunable color filters will be made from ferro-electric liquid crystals (FLCs), whose fast, low-power switching permits filter programming well within the 10 ms allowed for three primary colors at video frame rate (30 Hz). This electro-optic filter could be combined with any broad-spectrum display to give multicolor images. FLCs can also be used to make the information-containing flat panel itself; the resulting display's fast switching capability makes it especially well suited to the frame-sequential color concept. The project will develop the color filter during Phase I and integrate filters with monochrome flat panels into full-scale displays during Phase II.

Potential Commercial Applications: Economical, low-power, multicolor, flat-panel displays could replace CRTs in many applications where small thickness and low power consumption would be advantageous .

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152
88-1-09.05-3200
A Lightweight Non-Metallic Heat Pipe Radiator
Foster-Miller Inc.
350 Second Avenue
Waltham, MA 02254
John McCoy (617-890-3200)
JSC -- NAS9-18098

This project investigates the feasibility of building a non-metallic heat pipe radiator (NMHPR) for space applications. The concept to be evaluated builds upon a hybrid, coupled, heat-rejection concept but improves on it by increasing the modularity of the system and the possibility for post-launch assembly and in-place repair. The principal purpose for utilizing lightweight, non-metallic radiator elements is an estimated 80 percent savings in radiating fin weight over current systems. The radiator will be made of either a stiff, tough, high-strength polymer, carbon-epoxy bonded compound or other material. The Phase I effort will concentrate on mechanical and thermal design of the NMHPR, as well as an investigation of compatibility of materials and working fluids in a space environment. It will be augmented by experiments on radiator element manufacturing techniques and heat transfer characteristics across a solid interface where the radiator elements attach to the thermal transport leg.

Potential Commercial Applications: These radiator elements may reduce per unit price for use in space. Other commercial applications are not envisioned.

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*** 153**
88-1-09.06-3200
Binary Mixtures for Spacecraft Heat Transport
Foster-Miller Inc.
350 Second Avenue
Waltham, MA 02254
Glen I. Deming (617-890-3200)
MSFC -- NAS8-38050

The concept addressed in this project is a novel heat transport loop for heat rejection from space vehicles for thermal management. Waste heat rejection techniques currently being considered use a single-phase, liquid-water loop for removing heat generated inside the space vehicle. The internal loop interfaces with an external, single-phase, liquid heat transport loop which carries the waste heat to body-mounted radiators for rejection to space. The proposed concept is to replace the external single-phase liquid working fluid with a nonazeotropic, binary mixture utilizing a two-phase pump. Advantages gained through the use of a two-phase, binary mixture working fluid are: a non-isothermal phase change, high heat transfer coefficients, high heat of vaporization, low fluid flow rates, and temperature and capacity control via composition shifting. These properties lead to potential reductions in both pumping power consumption and system weight.

Potential Commercial Applications: The potential improvements in cycle efficiency, capacity, and capacity modulation in heat pumps and refrigerators could increase market size. Several systems have been commercially marketed with limited success.

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154
88-1-09.06-6576A
Vented Nozzle Concept for Optimum Performance of Launch Vehicles
CFD Research Corporation
3313 Bob Wallace Avene, Suite 205
Huntsville, AL 35805
Andrzej J. Przekwas (205-536-6576)
MSFC -- NAS8-38034

The vented nozzle is an innovative concept to modulate the nozzle flow area during flight of a launch vehicle and improve the nozzle performance. The nozzle walls are vented through a series of spring loaded check valves to allow continuous and passive adjustment of exhaust to ambient pressures and to reduce the transient start loads on the nozzle. In Phase I, an existing CFD code will be used to examine the feasibility of the concept. A spacecraft nozzle, such as the SSME nozzle, will be analyzed with

several vent configurations. Performance parameters and flow distributions will be studied for several pressure ratios to simulate operation at various altitudes. Effects of protrusions in the flow, introduced upstream of check valves to enhance the reliability of their operation, will also be analyzed. In Phase II, operational questions such as side loads due to failed valves would be analyzed and an optimum nozzle design would be developed and tested. The adapted CFD code may also serve as a valuable design tool.

Potential Commercial Applications: Applications would only be in the design of rocket nozzles for launch vehicles.

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* **155**
88-1-09.07-4000
Stirling Cryocooler for Unmanned Space Applications
Stirling Technology Co.
2952 George Washington Way
Richland, WA 99352
Peter Riggle (509-375-4000)
GSFC -- NAS5-30458

The goal of this project is developing and testing a technology demonstration model (TDM) of a long-life, virtually vibration-free Stirling cryocooler for cooling sensors to the 65 - 80 K temperature range. Flexural bearings and gas clearance seals provide the potential for 10- to 15-year life. Vibration will be reduced to trace levels by counter-oscillating components, complete symmetry, and matching of the magnetic, mechanical, and electrical impedances of the opposed components. Design studies will determine the ability of drive circuit arrangements to reduce residual vibration to a minimum. A high coefficient-of-performance will result from thermodynamic optimization and use of high-efficiency mechanical components, linear electric motors, and drive circuitry.

The Phase I objective is completion of the TDM conceptual design. This includes component sizing, establishing the physical parameters and electrical circuits to achieve low vibration, preparation of a conceptual layout, and a summary of the expected performance. Phase II would culminate in the delivery of one TDM to NASA for bench testing.

Potential Commercial Applications: Applications could be in cooling sensors for night vision units, small cryocooled computers, cryosurgery, and small vacuum pumps.

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156
88-1-09.07-4942B
Novel Cryocooler Regenerator Designs
Frederick A. Costello Inc.
12864 Tewksbury Drive
Herndon, VA 22071
Frederick A. Costello (703-620-4942)
GSFC -- NAS5-30595

Three novel regenerator concepts that have the potential for significantly improving the coefficient-of-performance of Stirling-cycle cryocoolers at temperatures below 20 K will be designed and evaluated. The innovations consist of two types of active regenerators and a novel combination of materials that yield a high specific heat even at low temperatures. The active regenerators act as if they have an infinite specific heat. The three concepts are important to NASA's various missions. Many NASA payloads depend on cooling infra-red sensors to temperatures on the order of 2 K. Such temperatures can currently be attained only with refrigeration that uses liquid helium as the working medium. The proposed concepts can reduce significantly the cost of liquid helium in space. For example, the cost of producing liquid helium on Earth would be decreased. More importantly, helium cryocoolers may become practical in space, whereas currently they are so impractical that helium must be re-supplied from Earth.

Potential Commercial Applications: The results could be used by companies that supply cryocoolers and helium and in terrestrial cryogenic applications such as superconducting magnets for fusion reactors.

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* **157**
88-1-09.07-4942C
Computing Radiant Interchange Among Real Surfaces
Frederick A. Costello Inc.
12864 Tewksbury Drive
Herndon, VA 22071
Frederick A. Costello (703-620-4942)
GSFC -- NAS5-30495

A computer program to determine the thermal radiant interchange factors among real, non-diffuse, non-specular surfaces will apply an innovative, one-step procedure which yields an exact solution to the computational problem. Since current programs based on ray-tracing, Monte Carlo simulations, and stray light methods are costly, cumbersome, and inaccurate for non-ideal surfaces, spacecraft designers usually apply simple pure-diffuse/pure-specular models which incur unknowable inaccuracies and uncertainties in design adequacy. The computer program, to be completed in Phase II, could provide a valuable radiator design tool for NASA missions. For example, a radiator on the moon that uses non-diffuse reflectors to divert sunlight could achieve a sink temperature of -16 °C; whereas, today's flat-plate radiator designs can achieve only 35 °C -- so high that a heat pump would be needed. Similar improvements are possible with non-diffuse reflectors for radiators operating at 80 K.

Potential Commercial Applications: This program would be sold via the firm's catalog of sophisticated computer programs to thermal engineers for design of space radiators and precision optical systems.

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* 158
88-1-09.07-7003
Modular Chemical-Mechanical Heat Pump for Spacecraft Thermal Bus Applications
Mainstream Engineering Corp.
200 Yellow Place
Rockledge, FL 32955
Robert P. Scaringe (407-631-3550)
GSFC -- NAS5-30519

The intent of this project is to demonstrate an innovative, high-efficiency, high-reliability heat pump for spacecraft heat-rejection applications. This heat pump would allow equipment to operate at a temperature close to but different from the saturation temperature of a two-phase thermal bus. The proposed heat pump applies a hybrid, chemical-mechanical concept and is applicable to either thermally driven or electrically driven applications. As a starting point, the electrically driven design has been proposed for this project. Previous efforts by the company have identified a series of working fluids that are superior to existing working fluids in terms of thermodynamic performance and stability. Phase I will address the design of this innovative heat pump. The subsequent Phase II effort will address the final design, construction, and testing (in normal gravity and reduced gravity) of this innovative, modular, chemical-mechanical heat pump.

Potential Commercial Applications: (None suggested by the company.)

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159
88-1-09.09-4995
Surface Acoustic Wave Device for Wide Angle Laser Scanning
APA Optics Inc.
2950 84th Lane, NE
Blaine, MN 55432
Steven M. Arnold (612-784-4995)
JSC -- NAS9-18084

An advanced, integrated, acousto-optic laser scanner to support terminal rendezvous, station-keeping, and docking in space is being developed in order to overcome the limitations of acousto-optic Bragg cells. The new scanner introduces several innovations: use of GHz surface acoustic waves (SAWs) on piezoelectric thin-film waveguides with broadband Bragg phase matching to increase the field-of-view and improve the overlap between acoustic- and optical-guided waves; cascading of SAW gratings to increase further the field of view; and a phase-locked, diode laser array to provide watts of power without a prism coupler or waveguide collimating lens. The use of high-spatial-frequency SAW gratings may permit deflecting light out of the plane and result in true two-dimensional scanning. Phase I consists of analysis of the scanner concept and tests to determine acoustic power requirements for efficient deflection of a laser beam.

Potential Commercial Applications: Examples are: non-impact printing, color imaging and digitizing, range finding, laser radar, bar code reading, character recognition, robotic vision, and optical inspection.

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160
88-1-09.09-8050
A High-Precision Sun-Tolerant LIDAR
Holometrix Inc.
99 Erie Street
Cambridge, MA 02139
P. G. DeBaryshe (617-868-8050)
JSC -- NAS9-18096

A pulsed, laser-diode LIDAR system is expected to have the following potential: single-pulse, sub-centimeter range accuracy; immunity to solar background; target discrimination; adaptive windowing; eye safety at the aperture; multi-thousand-per-second pulse rate for accurate velocity determination; and extendibility to video-rate, three-dimensional tracking. The major innovation is in achieving accuracy needed by several applications such as: rendezvous and docking with a range-controlled wide field-of-view for scannerless attitude control; short range maneuvering and station keeping; tracking and imaging for Space Robot Rescue and Retrieval Mission; and work site positioning and robotic arm control. Continuous wave LIDARs cannot simultaneously satisfy these needs; existing pulsed laser rangers are insufficiently accurate. A single control unit applicable to most pulsed sources, laser or radar, will be developed. Timing improvements will be made to near-standard ranging equipment to achieve 5 mm-to-1 cm single pulse accuracy. This will provide a baseline system which is well adapted to a variety of NASA mission requirements.

Potential Commercial Applications: Applications could occur in high-data-rate velocity measurements, water surface profile measurements, mapping and profiling, and very long baseline surveying.

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* 161
88-1-09.09-9191
Worldwide Differential GPS for Space Shuttle Landing Operations
TAU Corporation
485 Alberto Way, Building D
Los Gatos, CA 95031
Peter V. W. Loomis (408-395-9191)
JSC -- NAS9-18108

The use of GPS (Global Positioning System) aboard the Space Shuttle in order to permit autonomous navigation would result in the ability to land in an emergency at any suitable airstrip. However, there will be no assurance that the chosen airstrip will have good visibility. Another concern is that the operation of GPS in a stand-alone mode offers no protection against a malfunctioning GPS satellite causing incorrect navigation. The innovation pursued in this project

addresses these two concerns. It will provide differential GPS to the Shuttle on a real-time, global basis. This will improve Shuttle's navigation accuracy and, in consequence, minimize the landing risk during periods of low visibility. The innovation will additionally provide integrity monitoring and management of the GPS systems concurrent with providing differential GPS correction terms. This will prevent the Shuttle receiver from using GPS satellites which are malfunctioning but have not been so identified.

Potential Commercial Applications: The largest user groups of this system would be the worldwide aviation and maritime communities and companies that could use it in oil and gas exploration.

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* **162**
88-1-09.10-8100
Autonomous Integrated GPS/INS Navigation Experiment for OMV
Mayflower Communications Company Inc.
80 Main Street
Reading, MA 01867
Triveni N. Upadhyay (617-942-2666)
MSFC -- NAS8-38031

The focus of this project is the development of an autonomous, integrated Global Positioning System and Inertial Navigation System (GPS/INS) that can be readily implemented in real-time on onboard computers to improve the total navigation performance of advanced Space Transportation Systems (STS). The GPS/INS concept combines the GPS interferometric carrier phase processing with the GPS inertial navigation filter processing to obtain accurate, continuous position, velocity, and attitude data for spacecraft. Continuous GPS tracking of advanced STSs will minimize ground tracking requirements and will provide flexibility in mission planning. This project will target the GPS inertial navigation filter development for the Orbital Maneuvering Vehicle (OMV). The rationale for selecting the OMV as the demonstration platform for this experiment is that the OMV will have onboard GPS receivers, two GPS antennae, and the receiver measurements will be available as an output for processing by the proposed navigation filter algorithms.

Potential Commercial Applications: Commercial applications currently exist for surveying, off-shore exploration, and maritime navigation.

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163
88-1-09.11-8600
Tethered Satellite Video Monitoring System
Applied Research Inc.
PO Box 11220
Huntsville, AL 35814-1220
Scott Davis (205-837-8600)
MSFC -- NAS8-38051

This project will design a video monitoring system for the measurement of tether dynamics in flight. This system will monitor satellite deployment and tether shape and will meet power, weight and temperature constraints of the spacecraft environment.

Potential Commercial Applications: This work could provides a basis for low cost, low power remote surveillance applications.

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* **164**
88-1-09.12-8442
A Low-Cost, CCD Solid-State Star Tracker
Applied Research Corporation
8201 Corporate Drive, Suite 920
Landover, MD 20785
Siegfried Auer (301-459-8442)
GSFC -- NAS5-30490

This project will develop a solid-state star tracker that can be reproduced at low cost. The design combines components and circuits developed for the video camera market with data processing and calibration methods developed for high-performance star trackers. The immediate application of this design is to provide users of space-borne payloads with an affordable, moderate- to high-performance star tracker.

Potential Commercial Applications: Applications would be in pointing payloads of sounding rockets, balloons, Spartan, the Space Shuttle, and Scout-class explorers.

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165
88-1-09.13-7070
Fiber-Optic Sensor Technology for High Altitude Balloons
Geo Centers Inc.
7 Wells Avenue
Newton Centre, MA 02159
Ian Aeby (617-964-7070)
GSFC -- NAS5-30491

Improvements in reliability of high-altitude balloon envelopes, which would increase their acceptance as equipment platforms, requires a thorough understanding of their failure mechanisms. The focus of this project is the use of fiber-optic strain sensors embedded into the envelope materials to provide a lightweight, cost-effective diagnostic system for monitoring strains within the envelope structure. Embedded strain sensors offer improved data accuracy over adhesively bonded sensors, and the small size of optical fibers produces a minimal impact on the mechanical properties and weight of the envelope. This project will develop the fiber-optic sensors and the methodologies for their application to the flexible, laminated polymer films of high altitude balloons. Existing and novel fiber-optic sensors will be laminated into balloon materials and tested. The results of these tests will then be used to develop strategies for integrating a

distributed fiber optic sensor network into an envelope to create an integrity monitoring system.

Potential Commercial Applications: Fiber-optic sensors could be applied to monitoring strains in tires used in aircraft and mass transportation vehicles and in flexible containers of flammable materials such as bladders in commercial aircraft fuel tanks.

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166
88-1-09.14-2974
Novel Fabrication of Superconducting Antenna Structures for Space
Monolithic Superconductors Inc.
PO Box 1654
Lake Oswego, OR 97035-9998
Lawrence E. Murr (503-684-2974)
GSFC -- NAS5-30504

Using explosive (shock-wave) fabrication techniques, this project will develop and fabricate simple monolithic, planar, sandwich arrays of superconducting $YBa_2Cu_3O_7$ powder or powder mixture in a copper matrix. These bulk, superconducting arrays will, in Phase I, serve as prototypes for simple antennas for microwave communications. Evaluations of array feasibility will be based on surface resistance measurements at 77 K over a frequency range of 0.5 to 5 GHz. The effect of mixing metal powders such as copper or silver on the superconducting $YBa_2Cu_3O_7$ surface resistance will also be evaluated as a means to engineer superconducting applications. These superconducting sandwich arrays will demonstrate scale-up potential to be pursued in Phase II and serve as practical precursors for significant improvements in the efficiency and operation of superconducting single-beam antenna configurations and related space applications of bulk superconductors.

Potential Commercial Applications: Superconducting sandwich arrays in a metal matrix or light-weight alloys could have applications such as magnetic field shielding.

***

10 SPACE POWER

167
88-1-10.01-2221
A Test Rig for Measuring Thermal Performance of Stirling Cycle Regenerators
Sunpower Inc.
6 Byard Street
Athens, OH 45701
Gary Koester (614-594-2221)
LeRC -- NAS3-25620

Design, data reduction analysis, fabrication, and initial testing will be performed for a Stirling-cycle test rig capable of measuring thermal flux across regenerators under oscillating flow conditions similar to those encountered in modern Stirling machines. This will be achieved by the addition of a heat-transfer subassembly to an existing pressure-drop test rig. Both the rig and the data reduction procedure are innovative. The rig will be particularly simple and straight-forward, and the data reduction process will enable, for the first time, both gas-to-matrix heat transfer and apparent axial conductivity to be measured simultaneously.

Potential Commercial Applications: Accurate regenerator-heat-transfer design correlations could improve Stirling machines for all applications and apply to other fields where oscillating-flow heat transfer in porous materials is important.

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168
88-1-10.01-3200A
Improved Thermal Energy Storage System for Solar-Dynamic, Space-Power Generation
Foster-Miller Inc.
350 Second Avenue
Waltham, MA 02254
Philip Stark (617-890-3200)
LeRC -- NAS3-25558

The use of high-temperature, phase-change materials (PCM) for transient thermal storage in space solar power plants encounters the major technical issue of containment of the PCM. This project will study a new, promising approach for PCM containment that offers potentially significant advantages over other containment systems. The innovation is to incorporate a metallic PCM into thin, highly porous sheets of carbon-carbon composite by hot isostatic pressing. The carbon-carbon sheets containing the PCM are then encapsulated in a thin, compatible coating of Si_3N_4. For Phase I, with germanium selected as the metallic PCM, the project will evaluate the feasibility of incorporating a high-temperature PCM into carbon-carbon. In addition, the Si_3N_4-encapsulated, germanium, carbon-carbon composite heat-storage system will be evaluated in terms of its thermal characteristics and its mechanical and chemical stability under freeze-thaw cycling.

Potential Commercial Applications: Immediate applications could be aboard high-power spacecraft for military missions. In the longer-term, with the eventual commercialization of space, the technology could be applied by the private sector.

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*** 169**
88-1-10.01-6696
A Technique for Fabrication of Low-Cost Epitaxial Indium Phosphide Solar Cells
Kopin Corporation
695 Myles Standish Blvd.
Taunton, MA 02780
M. B. Spitzer (508-824-6696)
LeRC -- NAS3-25610

This project addresses the development of an indium-phosphide solar cell yielding high radiation

resistance, low weight, and low fabrication cost. The approach combines the use of a concentrator design with films formed by the cleavage-of-lateral-epitaxial-films-for-transfer (CLEFT) process to obtain high efficiency, low weight, and recovery of the substrate. In Phase I, the feasibility of the concentrator and CLEFT approach will be tested. In Phase II, in-depth research will be carried out to develop the CLEFT techniques and to improve the concentrator cell design.

Potential Commercial Applications: The proposed innovation would be useful for space satellite power systems requiring radiation-resistant photovoltaic cells.

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170
88-1-10.01-7270A
Cathode Catalyst Support Materials for High Temperature Alkaline Fuel Cells
Giner Inc.
14 Spring Street
Waltham, MA 02254-9147
S. Sarangapani (617-899-7270)
LeRC -- NAS3-25621

This project aims to develop nickel-oxide-based catalyst supports to be used in Teflon-bonded, oxygen cathodes of hydrogen-oxygen fuel cells capable of operating at temperatures of 150 °C and higher. In contrast, present-day space fuel cells operate at temperatures of less than 90 °C. The higher temperatures increase the overall efficiency of the fuel cell system by reducing over-voltage (mostly of the oxygen electrode) and the IR drop. Techniques to prepare lithiated nickel oxide of adequate surface area and conductivity along with procedures for adding catalysts will be developed. Porous, Teflon-bonded electrodes will be fabricated using this material, and their electrochemical performance evaluated. At the end of the Phase I program, the feasibility of nickel-oxide-based material as cathode catalyst support for high-temperature fuel cells may be established.

Potential Commercial Applications: Increased efficiency of alkaline fuel cells may find applications in transportation and on-site power units fueled with hydrogen.

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* **171**
88-1-10.02-9450
Long Cycle Life Rechargeable Lithium Batteries
EIC Laboratories Inc.
111 Downey Street
Norwood, MA 02062
K. M. Abraham (617-769-9450)
JPL -- NAS7-1042

New strategies will be explored to significantly improve the cycle life of ambient-temperature, rechargeable lithium cells. Experimental studies of representative cell systems to demonstrate feasibility of the approaches will be carried out in Phase I. The principal aspect of the new strategies is concerned with the use of alternative anodes, instead of pure lithium-metal anodes, in ambient-temperature, rechargeable, lithium batteries.

Potential Commercial Applications: Potential uses could be in communication devices, robots, hand-held tools and, ultimately, electric vehicle propulsion.

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* **172**
88-1-10.04-3666
Fabrication of Photovoltaic Laser Energy Converter by MBE
Electro-Optek Corporation
3152 Kashiwa Street
Torrance, CA 90505
William S. Chan (213-434-3666)
LaRC -- NAS1-18813

An innovative approach will be applied for fabricating series-connected, multiple, vertical p-n junctions on silicon by molecular beam epitaxy (MBE) for converting a high-intensity laser beam (one kilowatt per square centimeter) to electrical power in space-based laser power transmission. This approach involves precisely controlling the epitaxy of alternating layers of cobalt-silicide, p-doped Si, and n-doped Si to form a single-crystal structure containing 500 to 1000 p-n junctions per cm connected in series. Special E-beam-assisted, heated Knudsen sources will be used to perform the multilayer epitaxy to minimize the occurrence of pinholes in the silicide layers and to achieve abrupt p-n junction growth over a long MBE growth period. The cobalt silicide thus formed will have an ultra-low resistance of less than a milli-ohm necessary for high conversion efficiency.

Potential Commercial Applications: Applications could include laser power converters, radiation detectors, and microelectronics.

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173
88-1-10.05-1319
Fault Tolerant Space Power Control Algorithms Using Neural Networks
Systematix Inc.
5029 Edmondson Pike
Nashville, TN 37211
Steven W. Welch (615-834-1319)
MSFC -- NAS8-38049

The application of neural computing to the design of highly reliable, space-power systems is addressed by using neural network techniques to implement a set of conventional control algorithms. This set will include the classical PID (proportional integral derivative) control algorithm, latching and non-latching alarm blocks, and current-time functions. Conceptually the neural-based control system building blocks will perform like their traditional counterparts which are well-understood and commonly used by system designers. The underlying implementation, however,

will be founded on highly distributed neural networks designed to run as software in a network of microprocessors with the potential for adaptation to dedicated neural processors. The ultimate goal is the integration of highly developed and well-understood power control techniques with neural systems, whose inherent fault tolerance, speed, and light weight are advantageous in space applications.

Potential Commercial Applications: Applications could include power distribution networks, power plants, chemical processing, environmental systems, security systems, traffic control, aircraft power units, medical life support, and automated manufacturing.

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* **174**
88-1-10.05-9685
Control of Resonance in a 20 kHz Space Power System
P. C. Krause & Associates Inc.
1414 Ravinia Road
West Lafayette, IN 47906
Paul C. Krause (317-463-9685)
MSFC -- NAS8-38035

The 20 kHz power systems currently being considered for the Space Station and advanced spacecraft can produce harmonic resonances which, in some cases, may cause component damage and electromagnetic interference. Controlled suppression of these harmonic resonance frequencies is the purpose of this project, which will investigate methods of filtering the harmonic frequencies by using either passive or active filtering at the load and/or source interface. Phase I will provide the means for filter design and set the stage for Phase II. This Phase would develop detailed models of typical spacecraft power systems in order to establish a simulated test bed for designing and evaluating autonomous systems before committing to hardware. A second aspect of Phase II would be development and verification of reduced order models of the power system components for use in a digital simulation of the overall system.

Potential Commercial Applications: This could have application in any group, federal or commercial, interested in the design and operation of a 20 kHz power system for aircraft of any type.

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* **175**
88-1-10.06-2681
Fabrication of Multifilament Conductors: CVD Processing of High T_c Superconducting Composite Fibers
Advanced Technology Materials Inc.
520-B Danbury Road
New Milford, CT 06776
Peter S. Kirlin (203-355-2681)
MSFC -- NAS8-38023

A suitable manufacturing technology for bulk superconductors is crucial for their use in aerospace power and propulsion applications. State-of-the-art processing of bulk, high-temperature superconductors (HTSC) gives a brittle material with low current-carry capacities whereas HTSC thin films show current densities exceeding 10^6 amps/cm^2. The innovation is to utilize a thin film deposition technique to fabricate the superconducting component of a bulk conductor. This will be achieved by depositing high-quality BiSrCaCuO films by metal-organic chemical vapor deposition on platinum-coated tungsten fibers. The current carrying capacity of the superconducting layer should approach that achievable in thin films, and the mechanical properties of the composite fibers will be dominated by the high strength of the tungsten core. In Phase II, continuous processing will be developed and the resulting fibers used to fabricate a multifilament conductor with electrical and mechanical properties suitable for aerospace applications.

Potential Commercial Applications: This project could lead to the application of high temperature superconductors in large magnetic fields.

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176
88-1-10.06-6000
Preparation of Superconducting Wire
Spire Corporation
Patriots Park
Bedford, MA 01730
Anton C. Greenwald (617-275-6000)
MSFC -- NAS8-38039

Chemical vapor deposition of $YBa_2Cu_3O_x$, or similar material, on a coated tungsten filament is an innovative technique for fabrication of ceramic superconducting wire. Metal-organic sources for the metals will be deposited in an atmosphere containing oxygen so that unwanted species will be volatilized, *e.g.*, as CO_2, and the final film may not require sintering. The filament, coated to prevent oxidation and to maintain electrical contact to the 10 - 20 micron thick film, will be uniformly heated by passing a current through it. The Phase I objective is to demonstrate deposition of $YBa_2Cu_3O_x$ on a stationary wire with the correct ratio of metals and to test for superconducting properties. Phase II objectives would be to continuously coat a wire moving through the reactor with a layer having a transition temperature over 93 K and a critical current density over 10^5 A/cm^2 at 77 K. Filaments thus produced would be twisted into larger diameter wire for use in magnets and other end products.

Potential Commercial Applications: Superconducting wire with a high critical current density at 77 K in a 10 Tesla magnetic field would be useful in generators, motors, energy storage systems, and magnets.

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177
88-1-10.06-7241
Electromagnetic Insulators
Magnetic Concepts
10313 Ridgemoor Drive

Silver Spring, MD 20901
Philip A. Studer (301-593-7241)
LeRC -- NAS3-25614

This innovation is based on the Meissner effect to improve the performance and reduce the weight, size, and power of spacecraft power and propulsion equipment by greatly reducing magnetic flux leakage in motors, actuators and other electromagnetic devices. It will utilize the most advanced form of high-Tc superconductors--thin films. The objectives are to demonstrate the feasibility of passive flux containment, to provide design data, and to evaluate expected device performance improvements. Cooperative efforts with NASA engineers are suggested to apply techniques to hardware of current interest so that immediate results will be available from a Phase II effort.

Potential Commercial Applications: Application may occur in cryogenic liquefaction machinery, in vacuum process systems, and in high efficiency motors and alternators.

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178
88-1-10.06-8629
Current Leads for Superconducting Magnets
Alabama Cryogenic Engineering Inc.
P.O. Box 2470
Huntsville, AL 35804
John B. Hendricks (205-536-8629)
JPL -- NAS7-1059

The new high T_c superconducting materials can be used to construct current leads for conventional superconducting magnets. This is a relatively simple system that will not place large demands on the material or on the fabrication process. However, the use of superconducting leads can result in substantial improvements in heat leaks.

Potential Commercial Applications: The innovation could have applications in systems that use superconducting magnets.

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179
88-1-10.06-9450
High-Temperature Superconducting Composites
EIC Laboratories Inc.
111 Downey Street
Norwood, MA 02062
Stuart F. Cogan (617-769-9450)
GSFC -- NAS5-30494

A high-T_c composite with the superconducting performance and mechanical properties necessary for practical spaceborne applications is the goal of this project. A process will be developed for fabricating continuous filament high-T_c and high-J_c composites stabilized with an aluminum matrix through crystallographic texturing developed from molecular-level sol chemistry. To achieve useful current densities, the microstructure of the superconducting filaments will be tailored to accommodate the crystallographic orientation dependence of J_c, superconductivity across grain boundaries, magnetic field dependence of J_c, and the stabilization requirements of the superconducting state. High-J_c filaments will be produced by low-temperature extrusion of a highly oriented precursor polymer followed by a reaction heat treatment to form the high-T_c phase. Thermally and mechanically stabilized composites will be formed by liquid metal infiltration of multifilament bundles. The Phase I program seeks to demonstrate the production of crystallographically oriented high-J_c filaments of $YBa_2Cu_3O_{7-x}$. Multifilament production and composite fabrication would be undertaken in Phase II.

Potential Commercial Applications: Anticipated uses include plasma confinement, energy storage rings, transmission of electrical power, superconducting generators, and related electrical machinery.

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11 SPACE PROPULSION

* **180**
88-1-11.01-8900B
Generalized Failure Criteria for Laminated Carbon-Carbon
PDA Engineering
2975 Redhill Avenue
Costa Mesa, CA 92626
Douglas A. Marx (714-540-8900)
MSFC -- NAS8-38025

The WESTAR/PALAPA satellite launch, in which two-dimensional, carbon-carbon (C-C) rocket nozzle exit cones failed and caused a loss of mission, points to the need for a better understanding of the mechanical behavior of two-dimensional C-C materials. This project will address this need by evolving a physically based failure criterion. Establishment of a physical basis is the key which will make the results useful in all facets of the mechanical engineering of two-dimensional C-C materials including processing, inspection, and testing. Much of the test data on two-dimensional C-C materials needed for this project are available, but past activities have only begun to illuminate the physical factors influencing stress-state interactions and material strength variability. This project will study existing data and conduct the additional work to develop a methodology which will lead to the desired level of confidence in solid rocket motor reliability.

Potential Commercial Applications: A failure criterion for laminated C-C materials could be applied in a commercial product used by NASA and its contractors.

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181
88-1-11.03-0688
Liquid Rocket Atomization: An Innovative Numerical and Experimental Simulation
MetroLaser

18006 Skypark Circle, #108
Irvine, CA 92714-6428
Cecil F. Hess (714-553-0688)
MSFC -- NAS8-38043

This project is a theoretical and experimental investigation of the fluid dynamics of interacting liquid jets in liquid-fueled rocket engines. The theoretical model, based on a vortex-dynamics algorithm, takes advantage of the fact that, in many flows, vorticity is concentrated in a small sub-domain of the flow field. By portraying the actual vorticity distribution as discrete vortex elements and then following the evolution of the vorticity field, one may obtain a complete flow description limited only by the accuracy of the discreting process. This model will be extended during Phase I to investigate two co-flowing, shearing planar liquid jets and two impinging, opposed, planar liquid jets. The experiments conducted during Phase I will attempt validation of the numerical model with holographic instrumentation. This work, if carried through Phase II, will result in numerical and experimental tools which will lead to more efficient atomizers, and a better understanding of atomization and mixing.

Potential Commercial Applications: This work could be applied in diesel fuel atomization, gas turbine nozzles, agricultural sprays, and rapid solidification processes.

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* **182**
88-1-11.03-1966
The Chemical Kinetics of LOx/Hydrocarbon Combustion
Software and Engineering Associates Inc.
1000 E. William Street, Suite 200
Carson City, NV 89701
Gary R. Nickerson (702-882-1966)
MSFC -- NAS8-38052

Analytical methods and computer software will be developed for characterizing the chemical kinetic mechanisms that control LOx-hydrocarbon combustion in rocket engines. An innovative and highly general method will be applied to model combustion as it occurs in gas generators for pump fed engines. The method will then be extended to model other non-equilibrium processes, for example, the injection of gas generator exhaust into the primary nozzle boundary layer and its effect on performance and wall cooling. Other areas to be examined are: sooting, ignition, oxygen-rich combustion, and the relationship between kinetics and mixing. A generalized chemistry package coupled to an implicit, stable numerical integration package will be used. The Phase I effort will provide a "proof-of-concept" and a study plan for Phase II that should result in a valuable design tool for the development of large liquid rocket engines.

Potential Commercial Applications: The results of this project may allow substantial cost savings in the development of liquid rocket engines.

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183
88-1-11.03-8122
Finite Element Code for Combustion Analysis of Advanced Propulsion Systems
Huntsville Sciences Corp.
3313 Bob Wallace Avenue, Suite 201
Huntsville, AL 35805
Lawrence W. Spradley (205-536-8122)
MSFC -- NAS8-38022

An advanced computational tool will be developed for analysis and design of advanced space propulsion systems by modelling the turbulent, finite-rate, reacting, two-phase flow in thrust chambers. Start-up and shutdown transients will be modeled with the time-accurate algorithm. Finite elements will be used with a flux-vector-split technique to provide a characteristic-based, upwind, fully implicit solution. The solution domain will include the subsonic, transonic, and supersonic nozzle flow and the exhaust plume.

The Phase I code will developed for axially symmetric flow of a single-phase gas with a finite-rate kinetics package for hydrogen and oxygen and a two-equation, turbulent, kinetic-energy closure model. In Phase II, the code will be extended to three dimensions, arbitrary kinetics, and multi-phase flow. The development will use an existing finite-element, flux-corrected transport code as a point of departure. The resulting code will provide a modern and efficient tool to analyze and to design or modify existing and future space propulsion systems.

Potential Commercial Applications: Commercial supersonic airplane development could use these computational codes to provide propulsion data, to reduce test costs, and to verify experimental measurements and design changes.

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184
88-1-11.04-4456
CAGD: Computer-Aided Grid Design
Program Development Corp.
300 Hamilton Avenue, #409
White Plains, NY 10601
Bharat K. Soni (914-761-1732)
MSFC -- NAS8-38037

As the trend continues towards exploiting the capabilities of the current generation of super computers to model complex, three-dimensional flow fields, there is need for advances in geometry modeling and grid generation technology to keep pace with advances in Navier-Stokes algorithms. The proposed Computer Aided Grid Design (CAGD) package is a step in that direction. The CAGD package will be developed on a scientific workstation by coupling a CAD graphics system and the existing grid generation codes with appropriate strategies. CAGD will offer a

fast, efficient, and economical approach to geometrical preparation. It will allow upgrading of the basic geometry in a step-by-step fashion interactively and under permanent visual control. It will minimize the differences between actual hardware surface descriptions and corresponding numerical analog. Along with geometry-grid definition for a typical CFD application, CAGD will also offer automatic boundary condition set-up for selected widely used Navier-Stokes algorithms utilized in internal flow configurations.

Potential Commercial Applications: The result could be a workstation-based, grid generation tool for design problems involving complex geometries.

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* 185
88-1-11.04-6576A
CFD Methods for Fast Flow Transients Encountered in Non-Linear Combustion Instability Problems
CFD Research Corporation
3325-D Triangle Boulevard
Huntsville, AL 35805
Andrzej J. Przekwas (205-5536-6576)
MSFC -- NAS8-38042

Rocket thrust chambers often experience combustion instabilities which may result in reduced performance, increased structural loads, and, ultimately, catastrophic failure. Existing analytical methods are generally limited to linear-combustion instabilities. Relatively little has been achieved to understand nonlinear combustion instabilities primarily because of lack of an accurate computational fluid dynamics (CFD) methodology. This project concentrates on developing fast, time- and space-accurate CFD methods for exact analysis of the nonlinear combustion instabilities. The innovative time-accurate method will be compared with the best existing numerical models. The technique will be evaluated on one-dimensional acoustic and combustion instability problems. Results will be compared with analytical solutions and available experimental data. In Phase II, the best technique will be incorporated in a CFD computer code to be used as a base for incorporating physical models of two-phase spray combustion models.

Potential Commercial Applications: Accurate prediction of nonlinear combustion instabilities could be used by all rocket manufacturers.

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12 HUMAN HABITABILITY AND BIOLOGY IN SPACE

* 186
88-1-12.01-52201A
Regenerable Biocide Delivery Unit
Umpqua Research Co.
PO Box 791
Myrtle Creek, OR 97457
Gerald V. Colombo (503-863-5201)
JSC -- NAS9-18113

The potable water system on the Space Shuttle uses a biocide generator as a microbial check valve (MCV). The MCV is a replaceable cartridge that is packed with a special iodinated ion-exchange resin which releases iodine into the water as it passes through the resin at a level essentially independent of flow rate and without need of instrumentation or controls. The present design capacity of the Shuttle MCV is approximately 30 days for a crew of seven.

The Space Station and other long-term missions will use reclaimed water to reduce the need for resupply. Investigations using the MCV on water representative of that produced by water recovery systems show that the MCV is capable of iodinating the water produced by these systems. In addition, feasibility tests have shown that the resin is capable of being regenerated in situ. A regenerable MCV would be a simple and reliable biocide dispenser that would not require frequent replacement of MCV cartridges.

Potential Commercial Applications: Regenerable iodinators could be useful to disinfect drinking water in remote campgrounds.

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* 187
88-1-12.01-8610
Development and Application of Liquid Membrane Emulsions in Cell Culture
BioChem Technology Inc.
66 Great Valley Parkway
Malvern, PA 19355
Lu-Kwang Ju (215-647-8610)
JSC -- NAS9-18086

The importance of cell culture is clearly indicated as new products derived from mammalian cells are introduced and the markets for these products grow. Since animal cells must be cultivated in low-shear environments, there is a serious problem of pH control in cultures of high cell concentrations. Lactic acid is mainly responsible for the problem. In perfusion culture systems, concentrations of lactic acid and other toxins or inhibitors can be kept at acceptably low levels. This, however, is not an efficient use of nutrients, which usually are not depleted.

This project aims to develop stable liquid membrane emulsions (LMEs) which can be applied to cell culture for pH control, lactic acid and other toxic or inhibitory material removal, and slow nutrient release to cells. Formation of LMEs will be studied by three different approaches: emulsification, oil-phase gelation or crosslinking, and encapsulation by coating around external/membrane phase interface. Application of LMEs will lead to more efficient cell cultures with high cell concentrations.

Potential Commercial Applications: This technology could be used in pharmaceutical and biotechnology industries involved in cell culture where separation

processes must be conducted under low-shear conditions.

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188
88-1-12.01-9396
A Whole Body Calorimeter for Space Station Astronauts
Geoscience Limited
410 S. Cedros Avenue
Solana Beach, CA 92075
Heinz F. Poppendiek (619-755-9396)
JSC -- NAS9-18095

A suitable direct calorimeter system for the measurement of metabolic outputs from astronauts in orbital laboratories would allow better understanding of such processes as changes in bone mineral content, muscle status, and the immune system as a result of weightlessness. The metabolic terms that can be accurately measured with a direct calorimeter would quantify the controlling processes being studied by NASA medical scientists.

This project includes preliminary design of two calorimeter systems, one with a rigid envelope and one with a non-rigid or disassemblable envelope, both designed to conserve space. The concepts would be analyzed mathematically and evaluated by some laboratory verification experiments. Final designs with back-up documentation would be delivered to NASA describing the system performances.

Potential Commercial Applications: The value of direct calorimetry in biomedical research at the Earth's surface has been amply demonstrated in the last ten years.

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189
88-1-12.02-2009
Organic Removal Module for Ultra-Pure Water Recycle Systems
Sievers Research Inc.
1930 Central Avenue, Suite C
Boulder, CO 80301
Richard D. Godec (303-444-2009)
MSFC -- NAS8-38045

The development of a system for the removal of organic compounds for high-purity water recycle based on semiconductor-catalyzed photo-oxidation will be conducted. The combination of a semiconductor-catalyzed photo-oxidation and an ion-exchange resin will permit the development of a simple, compact organic removal module which provides higher removal efficiencies (sub-parts per billion total organic carbon), lower maintenance, and substantially smaller size than existing systems using absorption on charcoal, other sorbents, or reverse osmosis. The proposed system will be particularly effective in the destruction and removal of low-molecular-weight organic compounds which are not efficiently removed using existing technologies. The organic removal module could be an integral component of a complete high-purity water recycle system for use in the Process Materials Management Systems in future space-based facilities.

Potential Commercial Applications: This approach for removal of organic compounds in high-purity water systems could be employed in electronics, pharmaceutical, and biotechnology industries.

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*** 190**
88-1-12.02-5201
Catalytic Methods Using Molecular Oxygen for Treatment of Waste Streams
Umpqua Research Co.
PO Box 791
Myrtle Creek, OR 97457
Gerald V. Colombo (503-863-5201)
MSFC -- NAS8-38038

Current treatment methods such as phase change, sorption and membrane separation techniques do not remove low-molecular-weight, polar organic molecules such as alcohols, ketones, and amides. A catalytic oxidation method using molecular oxygen is proposed that will oxidize these types of molecules to species that can be removed by existing treatment methods. The proposed catalytic oxidation method eliminates most of the disadvantages of other oxidizing schemes that have been investigated such as UV/ozone and supercritical oxidation.

The objective of this project is to develop a method using O_2 in conjunction with a catalyst to effect the oxidation of a wide variety of organic contaminants. Catalysts and conditions will be identified in Phase I which will lead to a Phase II effort resulting in a breadboard system for waste water treatment.

Potential Commercial Applications: This project could provide simpler, safer technology for condensate polishing and trace organic removal systems which are widely utilized in industry.

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*** 191**
88-1-12.03-4100
A Liquid-Sorbent/Membrane-Contactor Subsystem for CO_2 Removal
Bend Research Inc.
64550 Research Road
Bend, OR 97701-8599
Scott B. McCray (503-382-4100)
JSC -- NAS9-18085

Large crew numbers, long-duration missions, and severe launch and resupply penalties make the development of regenerative Environmental Control and Life Support Systems (ECLSS) a necessity for bases on the moon or Mars as well as for deep-space flights. The purpose of this project is to provide a subsystem of an ECLSS for continuous removal of carbon dioxide by means of a novel, membrane-based system. Instead of a polymeric membrane, this subsystem will use a microporous membrane (in a "membrane contactor" configuration) in combination

with a liquid sorbent for selectively removing CO_2 from air. This novel combination represents a lightweight, energy-efficient alternative to the current systems being developed by NASA--a significant advance in the state of the art. The Phase I effort will be the preliminary development of the CO_2 removal process.

Potential Commercial Applications: The technology to be developed in this project could be applied to extravehicular mobility units (EMU) and in submarines, military command centers, and high-altitude aircraft.

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* **192**
88-1-12.04-6780
A "Diet Expert Subsystem" Program for the Controlled Ecological Life Support System
Applied Sciences Consultants
621 River Oaks Parkway
San Jose, CA 95134
Ahmed Waleh (408-434-6780)
ARC -- NAS2-12991

Regenerative life support systems require reliable, stable means for recycling biological residues and regenerating the life-sustaining elements within a closed habitat. Prominent issues are dynamic control and prevention of instabilities caused by chaotic system behavior. An important, but unexplored, control problem in the Controlled Ecological Life Support System (CELSS) program is in meeting the crew's dietary needs considering both the overall system stability and subsystem instabilities that could become a health threat. Dietary planning, therefore, involves more than an optimization of food-values and requires a well-characterized expert subsystem that can be integrated with other subsystems of a "closed ecosystem."

Phase I will define an expert computer program that, if successful, can interface with other CELSS subsystems and determine, schedule, modify, control, and project both the daily and overall dietary needs according to a set of acquired rules from a cumulative data base. This expert system is a program that attempts to simulate the reasoning of a human expert given the same set of conditions.

Potential Commercial Applications: This project's results could be integrated into the CELSS for extended space missions.

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193
88-1-12.05-5801
Applications of an Automatic Inventory and Personnel Tracking System
Direct Current Light
15116 Gerkin
Lawndale, CA 90260
Stephen Dale Smith (213-973-5801)
JSC -- NAS9-18090

Astronauts, when in space, face many housekeeping chores, for example, tracking and control of inventories of equipment and food. Misplacement of items could prove fatal in crisis situations. Technology exists in the form of a 'proof-of-concept' breadboard system able to identify many different radio frequency (RF) tags within a specified area. This project will investigate the applications of the RF-tag technology towards a fully automated inventory tracking system to be used aboard the Space Station. In addition to material, the system could also monitor and locate astronauts within the Space Station.

The approach will be to design and construct a working breadboard to be tested under simulated conditions. Interference from equipment and space craft materials will be investigated. Benefits including ease of use of the system will be determined. Phase I research will provide the information to design a fully functional system in Phase II. Applications of this system extend to any situation where critical items must be tracked and located.

Potential Commercial Applications: The commercial applications include manufacturing and transportation industries and the military for any situations requiring tracking of critical inventory or personnel.

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194
88-1-12.05-8148
Vibration Isolation of Exercise Treadmill in Microgravity
Triangle R&D Corporation
PO Box 12696
Research Triangle Park, NC 27709
Amit L. Patra (919-781-8148)
JSC -- NAS9-18111

This Phase I project will investigate the technical feasibility of a means for vibration isolation of the treadmill aboard the Space Station which will allow astronauts to exercise in order to avoid or minimize calcium loss. At the present time, the treadmills used in space are man-operated to supply the requirement for daily exercise. Preliminary analysis, however, has indicated that the present system can transmit the vibration of running to the structure of the space ship and introduce undesirable vibrations or oscillations that could negatively impact sensitive onboard experiments. The solution will be the development of an active isolation system (shock absorbers) based upon superior damping characteristics of electro-rheological fluids. These shock absorbers could be placed beneath the exercise platform and isolate the vibration and noise from the floor of the space ship.

Potential Commercial Applications: Improved vibration and acoustic isolation could be applied in sensitive equipment such as used in optical, microelectronic and precision manufacturing.

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* 195
88-1-12.06-5201B
Single Phase Space Laundry
Umpqua Research Co.
PO Box 791
Myrtle Creek, OR 97457
Gerald V. Colombo (503-863-5201)
JSC -- NAS9-18112

The baseline design of NASA's Space Station includes a clothes laundry facility. Foaming and air entrainment in the microgravity of space cause serious materials handling problems. Anti-foaming agents add contaminants that must be removed in the water reclamation system. Phase separators add additional weight and power. To alleviate the requirements for phase separation and the problems associated with foaming, this project will pursue the development of a single phase laundering apparatus.

Clothes drying should be also accomplished in the same unit to minimize weight and space requirements of the laundering facility. Therefore, the laundering apparatus will include a clothes drying capability. The drying cycle will use microwave energy transfer to the wet clothing. Microwave drying offers several advantages: low power consumption, low lint production, and sterilization of clothes.

Potential Commercial Applications: Microwave drying could result in significant power savings, clothing sterilization, lower shrinkage, and low limit production.

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196
88-1-12.06-9200
A Multiple-Read SAW Tag Inventory System Development
Digital Signal Corporation
8003 Forbes Place
Springfield, VA 22151
John P. Cater (703-321-9200)
JSC -- NAS9-18089

Tracking of on-board Space Station and shuttle materials such as tools, food, clothes, pharmaceuticals and other expendables must be improved beyond bar code identification methods. This project proposes to create a Surface Acoustic Wave (SAW), passive-transponder, inventory tracking system with unique capability of simultaneous, multiple-tag read capability for reading up to 50 to 100 co-located tags. The small, lightweight and battery-less SAW transponder tags are ideally suited for automated inventory and tracking systems, but until now they have been limited to single tag-at-a-time read constraints. Phase I will investigate the feasibility of creating multiple-read tag systems so that items such as food containers can be accurately tracked in parallel or simultaneous fashion. The result of the project will be a feasibility, or proof-of-concept, working model of a multiple-read, SAW-tag automated inventory and tracking system.

Potential Commercial Applications: This technology could replace bar code inventory systems, making inventory and tracking systems automated and hands-free. Instantaneous grocery market checkout counters could be an early commercial market.

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197
88-1-12.07-8148
Spacesuit Glove-Liner with Enhanced Thermal Properties for Improved Comfort
Triangle R&D Corporation
PO Box 12696
Research Triangle Park, NC 27709
Yvonne G. Bryant (919-781-8148)
JSC -- NAS9-18110

This Phase I project will investigate fabricating an insulating material with enhanced thermal properties for improved thermal comfort of astronaut hands during extra-vehicular activity (EVA) in space. The approach involves incorporating phase change materials (PCMs) within a synthetic fiber matrix for later conversion into test fabric. At the phase change temperature, PCMs absorb and hold a high quantity of heat during the heating cycle which must be removed from the PCM before its temperature can begin to change. Thus, a glove insert fashioned from this material could significantly improve thermal comfort by preventing astronauts' hands from experiencing temperatures too much above or below the perceived thermal comfort zone improving, thereby, EVA performance. This material could also be applied to the manufacture of articles of clothing without the development of new technology. Phase I would investigate the technical feasibility for producing such a unique material and evaluate it in comparison to a control fabric.

Potential Commercial Applications: Insulating materials with enhanced thermal properties could be used in harsh environments where improved thermal comfort is needed.

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198
88-1-12.08-8141
A New Method For Respiratory Monitoring During Space Flight
Northwest Research Associates Inc.
PO Box 3027
Bellevue, WA 98009
Robert B. Fraser (206-453-8141)
ARC -- NAS2-12994

Since it allows non-invasive assessment of both pulmonary and cardiovascular health, respiratory gas analysis is a vital component of physiological monitoring of both humans and animals during extended space flight. This project addresses an innovative method of rapid multi-gas analysis which will lead to a rugged and compact respiratory monitor. The technique is based on the measurement of the intensity of the emission of selected spectral lines from a glow discharge.

Phase I technical objectives are to develop a suitable glow discharge tube and to build and test a prototype gas analyzer with this discharge tube as its basic transducer. The discharge tube designs will include various geometries and cathode materials selected to minimize cathode sputtering. The testing of the complete prototype analyzer will include measurement of range, linearity, signal strength, noise, repeatability, and response time. In Phase II, the addition of a flow module and display monitor, along with appropriate miniaturization, will lead to a complete and compact respiratory monitoring package.

Potential Commercial Applications: Applications include hospital bedside monitoring, mobile stress and exercise testing, environmental monitoring, and process control.

***

199
88-1-12.08-9339
Variable-G Facility for LIFESAT
Micro-G Research Inc.
3401 Market Street, Suite 345
Philadelphia, PA 19104-3323
David G. Heathcote (215-387-9339)
ARC -- NAS2-12973

Opportunities have been created recently for conducting biology research aboard free-flying satellites launched from expendable vehicles. This project is directed towards developing a centrifuge facility that can be accommodated within the LIFESAT free-flyer and that can satisfy a wide range of experimental needs of space biologists. The centrifuge facility will provide at least two independently-controlled rotors capable of providing g-force environments within the range of zero to somewhat above one while supplying simultaneous 1 g control data. The facility will have the ability to record video images of test specimens on the rotors together with other experimental and housekeeping data.

Specifications will be derived in Phase I from the scientific community and satellite interface requirements and used to prepare a preliminary design. A hardware development plan will be completed to provide an overview of how an engineering prototype version of the centrifuge facility could be fabricated and tested during Phase II.

Potential Commercial Applications: The centrifuge facilities would supply the background data required for the development of practical techniques for the production of food plants in space.

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*** 200**
88-1-12.10-4569
Remote Monitoring Indicators of Plant Stress
Agave Analytics
8726D S. Sepulveda, Suite B71
Los Angeles, CA 90045
Robert M. Woodhouse (213-840-4569)
KSC -- NAS10-11560

In space, where all resources including space and labor are scarce, it is essential that crop production be constantly and efficiently managed and that the health of the crop is determined quickly and accurately. The evaluation of crop health today depends largely on visual observations, judgments, and periodic destructive sampling. Remote sensing techniques, which are beginning to be used to examine crop growth, have difficulties in distinguishing multiple stresses. In order to use recently available sensors having high spectral resolution to distinguish individual stresses, it is necessary to develop algorithms which characterize individual stresses.

This project will utilize existing spectral data from controlled experiments to determine the feasibility of developing algorithms for evaluating crop health. With these algorithms, it will be possible to determine the health status of plants in real time. Knowing health status in real time from spectral algorithms makes efficient management possible with the potential of full automation of crop production.

Potential Commercial Applications: Commercial users could include greenhouse and growth chamber manufacturers and operators, environmental resource and consulting firms, investment and economic analysis companies involved with agricultural products, and farming or other agricultural enterprises.

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*** 201**
88-1-12.10-7070
Optrode Development for Environmental pH Monitoring
Geo Centers Inc.
7 Wells Avenue
Newton Centre, MA 02159
Mary Elizabeth Tabacco (617-964-7070)
KSC -- NAS10-11559

This project will develop a unique fiber-optic sensor for remotely monitoring environmental pH for NASA's Biological Science Operations both on Earth and in space. Fiber optic methods allow continuous, real-time, in-situ monitoring of vapors and are readily extended to work in liquid media.

Phase I will design and demonstrate, in the laboratory, a fiber-optic optrode capable of determining pH in an aquatic or physiological medium as may be required by developmental bio-reactors. Specific technical tasks are to: construct and evaluate porous-glass, fiber-optic sensors over a broad pH range (pH = 2-12); optimize the sensor for a specific pH range and determine indicator lifetime; develop methodology for chemical attachment; assess multiplexing methods and applicability to sensing of salinity and cations; and provide a preliminary design recommendation suitable for Phase II.

Potential Commercial Applications: This sensor could be used to monitor groundwater contaminants such as PCBs, dioxins, and toxic vapors as required by

OSHA and NIOSH. It could also be applied by chemical and pharmaceutical manufacturers in research, engineering, and process control.

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13 QUALITY ASSURANCE, SAFETY, AND CHECKOUT FOR GROUND AND SPACE OPERATIONS

202
88-1-13.01-1336A
Energy-Modulated Toxic Vapor Detector
Transducer Research Inc.
1228 Olympus Drive
Naperville, IL 60540
Joseph R. Stetter (312-974-2107)
KSC -- NAS10-11561

Modulation of the concentration of a toxic vapor generates in a detection device a time-dependent signal which usually is ignored and only steady-state or equilibrium detector values are used. However, this time-dependent signal contains very useful information about the identity and concentration of the toxic vapor. In this Phase I work, a prototype detector that operates using transient signals will be designed, constructed, and tested for analysis of monomethylhydrazine (MMH), hydrogen, and hydrochloric acid vapors, and its sensitivity, specificity, and stability will be evaluated. Since this technique is spectroscopic in nature and utilizes a differential measurement, the new detector is expected to be more stable and both reduce and simplify the maintenance and repair required of field instrumentation for toxic vapor detection.

Potential Commercial Applications: There need for highly selective and sensitive (ppb-level) detectors in medical monitoring, analytical instrumentation, environmental, industrial hygiene, and safety markets.

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* **203**
88-1-13.01-9450A
Real-Time Hydrazine Monitoring with Surface Enhanced Raman Spectroscopy
EIC Laboratories Inc.
111 Downey Street
Norwood, MA 02062
Martin W. Rupich (617-769-9450)
KSC -- NAS10-11557

Leakage of hydrazine and nitrogen tetroxide, used in large quantities in space operations, can present significant safety hazards to ground and flight crews. Because of their toxicity, concentrations of these materials must be monitored at the parts-per-billion level. The goal of this project is the development of a sensitive, "real-time" sensor for hypergolic gases based on Surface Enhanced Raman Spectroscopy (SERS). The SERS signal, which corresponds to the vibrational spectrum of a molecule adsorbed on specific metal or metal oxide surfaces, is obtained from the Raman scattering of a visible laser source. The SERS technique can be used for the qualitative and quantitative analysis of numerous components in both gaseous and liquid environments.

The goal of the Phase I program is to demonstrate the feasibility of a sensor based on SERS for the "real-time" detection of hydrazine and monomethylhydrazine. The design and testing of actual instruments would occur in Phase II.

Potential Commercial Applications: A gas phase sensor for detection and monitoring of hydrazine and its derivatives could be applied in the manufacture and commercial use of these toxic substances.

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204
88-1-13.02-2664
An Improved Quick Disconnect for Aerospace Fluid Systems
Micro Craft Inc.
PO Box 370
Tullahoma, TN 37388
Glenn Hardin (615-455-2612)
KSC -- NAS10-11556

To avoid unacceptable leakage in quick disconnect (QD) couplings used in aerospace fluid systems, this project will develop a method to verify remotely that proper sealing has been achieved in order to ensure the safety of personnel and flight hardware. This system would verify sealing of the QD prior to initiating fluid flow and, then, sealing of both the ground- and flight-half poppets prior to disconnect. The innovation for verifying sealing utilizes inherent features of current connector designs. Because QD connection and operation involves volume displacements, the concept is to monitor the associated pressure changes and employ this information to verify seal integrity. The objectives of this effort are to quantify the magnitude and repeatability of the pressure changes associated with QD operations and to expand the applications of the concept. These objectives will be accomplished by: performing experiments to obtain additional data on the pressure change characteristics of QD operations; improving QD operations; developing a closed-loop system for fail-safe operation; developing unique transducers; and evaluating the concept for other connectors.

Potential Commercial Applications: Applications range from the ground servicing of flight systems to on-orbit robotic satellite servicing.

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* **205**
88-1-13.02-7003B
Improved System for SCAPE Suit Heating
Mainstream Engineering Corp.
200 Yellow Place
Rockledge, FL 32955
Robert P. Scaringe (407-631-3550)
KSC -- NAS10-11565

Aerospace fuel and propellant handling during cold weather at Kennedy Space Center has resulted in lower than optimal temperatures inside propellant handlers' protective suits (SCAPE suit). The intent of this project is to demonstrate experimentally a prototype lightweight, non-contaminating, non-toxic, portable heat source that can be worn inside the suit without affecting mobility. This innovative SCAPE suit heating concept will interface with existing liquid air environmental control units (ECU). The heating unit has been designed to attach easily within the SCAPE suit and will only be attached during cold weather operations. This innovation will provide a comfortable suit environment so that workers will be able to perform critical tasks in an already stressful situation without the additional handicap of being too cold.

Phase I will result in the preliminary design of a lightweight, easily attachable SCAPE suit heating system for cold weather operations which will reduce SCAPE suit user fatigue and improve performance. The preliminary design will allow for two hours of automated operation.

Potential Commercial Applications: (None suggested by the company.)

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206
88-1-13.03-0070A
Investigation of the Triggering of Lightning by Launch Vehicles During Ascent
Electro Magnetic Applications Inc.
PO Box 260263
Denver, CO 80226-0263
Rodney A. Perala (303-980-0700)
KSC -- NAS10-11564

The specific objective of this project is to develop a triggered lightning model which has the ability to ascertain reliably the electrical threat to ascending launch vehicles. This will be accomplished through a series of specific tasks which examine all important aspects of the triggering phenomenon individually. These tasks will investigate: the microphysics of the discharge process; the effect of thunderstorm particles; the effect of global and local variations in air pressure; the effect of a rocket plume; and the conditions under which an arc occurs rather than a simple electrical corona. The results of the specific tasks will be integrated into a single triggered lightning model. This model, given the flight environment, will be able to predict whether triggered lightning can occur for a specific launch vehicle and will also be able to predict the effect on the vehicle if triggered lightning does occur.

Potential Commercial Applications: Prediction of triggered lightning potential when thunderstorms cannot be avoided will be of great interest to aviation industry.

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*** 207**
88-1-13.03-7800
A Mesoscale Statistical Thunderstorm Prediction System
MESO Inc.
28 Research Drive
Hampton, VA 23666-1325
Michael L. Kaplan (804-865-7800)
KSC -- NAS10-11562

A mesoscale statistical thunderstorm prediction system (MSTPS) for Kennedy Space Center will be developed to estimate the probability of thunderstorms during a specified two-hour period within a 10 km square area centered on KSC. The system will permit updated forecasts to be prepared from 24 hours to one-half hour in advance of the specified period. Thunderstorm probability will be determined through the use of a multivariable discriminant function with predictors selected according to their relative predictive power. Separate discriminant functions will be developed for each forecast time so that a gradual shift between the model and observational predictors can be achieved as one approaches the specified time. This project uses the mesoscale atmospheric simulation system dynamical model. Initial conditions will be set with a mesoscale three-dimensional analysis, and the model will be run for a 24-hour period to produce predictors. Observational predictors include standard surface weather reports and conventional radar echoes as well as data from systems such as VHF Doppler wind profilers, the NEXRAD Doppler radar network, automated surface observations, satellite imagery, and satellite soundings.

Potential Commercial Applications: Accurate, short-term prediction of thunderstorms and convection phenomena could improve operations and safety in aviation, land and sea transportation, agriculture, recreation, and construction. It could aid in planning scientific field studies, military exercises, missile launches, and military air base operations.

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208
88-1-13.04-6000
Thermal Tile Bond Inspection
Spire Corporation
Patriots Park
Bedford, MA 01730
Charles C. Blatchley (617-275-6000)
KSC -- NAS10-11558

During adhesive bonding of specially machined insulating tiles to the Space Shuttle Orbiter, the adhesive may crack, form voids, or simply fail to bond tightly to the surface. The goal of this project is to provide a reliable, nondestructive technique to determine the existence or size of bonding defects by applying gamma-ray scatter counting, used widely to measure thickness and composition of thin-film coatings. Unlike conventional radiography or radiometry, gamma-ray scattering requires access to just one surface and, through proper collimation, can be

made to ignore surface features and sense only defects in a layer deep under the surface. The apparatus for scanning these deep layers can be made extremely rugged and lightweight; detectors and electronics similar to those required for a hand-held inspection unit have been successfully boosted into space.

In Phase I, a breadboard gamma scatter unit will be tested for its capability of characterizing the condition of a layer of adhesive material. A prototype inspection device will be developed in Phase II.

Potential Commercial Applications: This approach for non-destructive inspection may also apply to industrial manufacturing, assembly, and operational inspections for other laminated configurations.

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209
88-1-13.06-7000
Air Mass Measurement Indicator for Portable Liquid Air Dewar
SRS Technologies
990 Explorer Boulevard, NW
Huntsville, AL 35806
Joe C. Cody (205-895-7000)
KSC - NAS10-11563

A measuring system capable of real-time display of the amount of air remaining in a liquid-air-respirator storage dewar, regardless of dewar orientation or use rate, will significantly enhance utilization and reduce unnecessary down-time for recharging. The measuring system consists of four instrumented tank supports providing signals to a microprocessor which converts the signals to forces and moments and resolves these into the total gravity force on the tank, from which the amount of air can be determined. Additional pressure and temperature measurements will allow the determination of the liquid and vapor mass. Low friction materials such as Teflon and anti-friction bearings may be used to minimize friction between the instrumented supports and supporting structure to improve system sensitivity.

In Phase I, the project will develop concepts for the instrumented beams, develop software to convert the measurements to weight of gaseous and liquid air, and define requirements for the microprocessor and display. This information will be integrated to provide an overall conceptual design of the system with supporting data to demonstrate feasibility.

Potential Commercial Applications: This development could be used for any life-support breathing equipment used in hazardous environments.

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* **210**
88-1-13.08-4770
Conducting Organic Polymer Environmental Sensor
Spectral Sciences Inc.
99 S. Bedford Street, #7
Burlington, MA 01803-5128
Mitchell Zakin (617-273-4770)
JSC -- NAS9-18107

A sensing device is required for the detection of toxic, hypergolic propellants (hydrazine, monomethylhydrazine, ammonia, and nitrogen tetroxide) on the surface of astronaut spacesuits and equipment in vacuum. A toxic vapor detector will be developed applying reagent-induced modification of the conductivity of doped, conducting polyaniline. The goal is an inexpensive, micro-sized device that can sensitively and selectively detect toxic hypergolic propellants. The COPES instrument would consist of two complementary modules: a supported polymer sample with appropriate electrical connections and an electrical measurement and data analysis unit. The basic operational principle is that exposure of doped, conducting polyaniline to specific chemical reagents produces changes in conductivity which are proportional to both reagent concentration and length of exposure. Phase I will provide a laboratory proof-of-concept demonstration of the COPES sensor and establish the design parameters for a breadboard COPES instrument to be constructed in Phase II.

Potential Commercial Applications: The sensor could be adapted for widespread use in the industrial sector for monitoring atmospheric pollutants and detecting chemical agents.

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14 SATELLITE AND SPACE SYSTEMS COMMUNICATIONS

211
88-1-14.01-0760B
Hybrid Projection Coding for the CCSDS Standard
SCS Telecom Inc.
107 Haven Avenue
Port Washington, NY 11050
Gary Lomp (516-883-0760)
JSC -- NAS9-18105

Design and software implementation of a new error correction coding technique is based on an extension of majority logic coding. The code has an algebraic structure that permits a hybrid code design and employs cyclic coding in a natural fashion within the basic code. The resulting hybrid code has increased random error correction capability while retaining the burst error correction capability. Decoding is accomplished by a simple iterative scheme wherein the number of errors is reduced significantly with each iteration. This project will extend the binary projection code theory pioneered by the firm into a hybrid code which has a code rate exceeding 0.9 and a block size of 10,000 bits, and can reduce an input bit error rate of 10^{-5} to an output bit error rate of less than 10^{-15}. The code will be designed so that it can be built to operate at 300 Mb/s using commercially available logic cell array chips.

Potential Commercial Applications: This project could have numerous applications including broadband ISDN, packet data switching, and satellite and meteor burst transmission systems.

***

212
88-1-14.01-1112
Multiple-Access Communication Hybrid Simulation
Q-DOT Inc.
1069 Elkton Drive
Colorado Springs, CO 80907-3579
David E. Reed (719-590-1112)
JSC -- NAS9-18103

An innovative technique will be developed to simulate the performance of multiple-access communication systems. A unique combination of Monte Carlo simulation and statistical bounding techniques are used to increase the efficiency of multiple-access models. Use of known statistics in the simulation model reduces the computational burden. When closed-form expressions for probability functions are not available, a recently developed bounding technique is used. This technique is extended to a larger class of problems giving greater flexibility than any other hybrid simulator.

Potential Commercial Applications: A general-purpose, multiple-access, communication system simulator could be useful in system performance predictions for many modern commercial systems.

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*** 213**
88-1-14.01-4341
Integrated EVA Antenna Module for Space Station Multiple Access Communication
Shason Microwave Corp.
1730 NASA Road 1, Suite 101
Houston, TX 77058
Roland W. Shaw (713-333-1950)
JSC -- NAS9-18106

The development of an integrated antenna module applicable for use on an extra-vehicular-activity (EVA), multiple-access communication system is being pursued in this project. The innovation is the merging of the circuitry, feed network, and antenna element into a common design capable of being mounted on the EVA backpack as a module plug-in component. The module utilizes an antipodal finline and balun to feed a balanced antenna element and still allow the active circuits to be implemented in MMIC (monolithic-microwave-integrated-circuit) technology. The manufacture of this miniature transmit-receive module will incorporate the use of new high dielectric materials with improved electrical and mechanical stability over temperature extremes. The use of high frequency plug-in connectors will also be implemented in the realization of the module.

Potential Commercial Applications: The manufacturing processes used on this project could apply to other phased array antenna systems. In addition, the frequency scalability of the design could make it applicable to "man-pack" systems.

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214
88-1-14.02-0755
Coherent Communication Link Using Diode-Pumped Lasers
Lightwave Electronics Corp.
1161 San Antonio Road
Mountain View, CA 94043
Thomas J. Kane (415-962-0755)
GSFC -- NAS5-30487

Optical communication links between geosynchronous satellites or between deep space probes and a Space Station would have the advantage of small antennas, low power consumption, and improved bandwidth and security compared to microwave links with similar capacity. Diode-pumped, solid-state lasers have the power, efficiency, and quality needed for these links and, in commercial efforts by the company, have been shown to have the characteristics required for use of coherent communication techniques such as heterodyne detection. This project will develop a 1.32-micron, single-frequency laser with an output of several hundred milliwatts. It will be coupled into a commercially available, guided-wave, phase modulator with a bandwith of 3 GHz. The modulated output will be heterodyne-detected using a five-milliwatt, single-frequency, quickly tunable laser which has been developed and phase-locked at the company. The problem of long-term frequency stabilization, which is a consideration determining system robustness, would be studied.

Potential Commercial Applications: The large power and improved detector sensitivity, made possible by diode-pumped, narrow-line-width lasers, could be valuable for applications such as undersea cables.

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*** 215**
88-1-14.02-2250
Multi-Access Free-Space Laser Communication System Design
Laser Data Technology Inc.
1244 Dielman Industrial Park
St. Louis, MO 63132
Monte Ross (314-997-2250)
GSFC -- NAS5-30599

This project will design multi-access, optical communication systems with small-size, light-weight terminals for use on GEO and LEO satellites. Incorporating advancing technology in high-power, coherent, gallium-aluminum-arsenide laser diodes and diode arrays, these designs will be simple, low-cost systems capable of gimbal-only tracking and direct detection. Laser transmitters will be designed using multi-watt laser diodes with efficiencies up to 50 percent to permit simultaneous transmissions from a number

satellites in LEO to a GEO satellite at data rates of one Mbps. The light-weight terminals will incorporate acquisition, tracking, and communications. Multi-access for the GEO satellite will rely on one large-aperture, wide-field-of-view, gimballed system terminal or on a number of two-inch-aperture, independently gimballed terminals. LEO terminals will use two-inch apertures and weigh thirty pounds. System and component specifications will be given and a risk assessment provided for the selected, balanced design concept.

Potential Commercial Applications: Low-cost, small, light-weight optical communication terminals could be applied in commercial satellites and in open-beam, line-of-sight communications from tower-to-tower or building-to-building.

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*** 216**
88-1-14.04-8000
Large Deviation Linear Phase Shifter
Pacific Monolithics Inc.
245 Santa Ana Court
Sunnyvale, CA 94086
Stephen P. MacCabe (408-732-8000)
JPL -- NAS7-1056

There is a requirement for large-deviation, linear, phase shifter circuits with QPSK and BPSK capability for use on-board in new spacecraft communication systems. A gallium-arsenide integrated circuit will be studied for this purpose. A circuit configuration will be defined for an X-band chip, and supporting circuitry and specifications necessary for the development of the chip during a follow-on phase will be defined. Circuit implications and design options for extending the work to Ka-Band region will be studied. Included in this effort will be a study of using HEMT circuits to form essentially the same circuit at higher frequency.

Potential Commercial Applications: High data-rate communication systems, telecommunications, and telemetry, both military and commercial, will benefit from the development of a chip featuring linear phase control, along with QPSK and BPSK capability.

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*** 217**
88-1-14.05-4114
Quartz/Fused Silica Chip Carriers
Holz Industries Inc.
5450 Complex Street, Suite 301
San Diego, CA 92123
Gary L. Holz (619-268-4114)
LeRC -- NAS3-25565

The rapidly growing use of GaAs MMICs (microwave monolithic integrated circuits) in space, defense, and commercial applications has created the need for packaging technology to maintain pace with semiconductor technology. Currently produced chip carriers are not capable of operating at the high frequencies (Ka band and above) demanded by many systems under development. A chip carrier manufactured from quartz/fused silica potentially offers many technological advantages over those of ceramic and metal. The objective of the proposed project is twofold: to prove the manufacturability of a quartz/-silica package and to prove the thesis that these packages exceed the performance capabilities of today's products. The work will consist of: testing the raw material; experimenting with methods of fabrication; producing prototypes in currently used package configurations; electrically and mechanically testing these prototypes.

Potential Commercial Applications: The anticipated result is a new generation of high speed packages, which could apply to supercomputers and space and military communications systems.

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*** 218**
88-1-14.05-9388
Innovative Pulse Compressors for Satellite Communications
Amerasia Technology Inc.
620-1 Hampshire Road
Westlake Village, CA 91361
Edward J. Staples (805-495-9388)
LeRC -- NAS3-25617

A chirp, Fourier-transform, compressive receiver employing new, innovative hyperbolic transducers and a single reflective array for pulse compression will be studied as an efficient, low-power means of demodulation for frequency-shift-keyed (FSK) satellite communications. The successful development of hyperbolic, in-line, reflective-array compressor filters will provide a breakthrough in compressive receivers which would be small, require low-power, and could be manufactured at 1/10 the cost of present systems.

A prototype satellite communications system will be designed to serve 250 channels simultaneously using 4-ary (1000 tones) with a tone separation of 50 kHz and covering a total bandwidth of 50 MHz. Each tone or chirp will have a maximum duration of 40 microseconds. The advantage of the proposed architecture is that it allows large-time-bandwidth signal processing to decode real-time communications of many simultaneous users with maximum efficiency and minimum size, power, and weight.

Potential Commercial Applications: The pulse compression system could be applied in Earth-to-satellite frequency multiplexed communications for television, banking, and business or private links. A truly low-cost system would make satellite communications sets available to large numbers of users.

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*** 219**
88-1-14.07-6901
Low Temperature Electrolytes for Emergency Locator Transmitter
Wilson Greatbatch Ltd.
10000 Wehrle Drive

Clarence, NY 14031
Esther S. Takeuchi (716-659-6901)
GSFC -- NAS5-30492

The anticipated result of Phase I is the development of an electrolyte for the lithium/silver-vanadium-oxide (Li/SVO) system that would provide cell performance at -40 °C as demanded by Emergency Locator Transmitters (ELTs) and Emergency Position Indicating Radio Beacons (EPIRBs). The LI/SVO chemistry was chosen due to its high volumetric energy density, good high-rate performance, low self-discharge, state of charge indication, excellent safety characteristics, and abuse resistance. Implementation of this chemistry would provide cells containing non-noxious electrolytes with the performance and safety characteristics desired for the applications mentioned. Phase II would involve the development of moderately priced, spirally wound cells suitable for assembly into battery packs for ELT and EPIRB use.

Potential Commercial Applications: These cells could be used in space applications, buoys, weapons systems, and other applications requiring high rates over wide temperature ranges.

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220
88-1-14.08-7111B
Pulsed Solid State Power Amplifiers for 30/20 GHz Satcom Terminal Up-Link Transmitter
LNR Communications Inc.
180 Marcus Boulevard
Hauppauge, NY 11788
Johannes deGruyl (516-273-7111)
LeRC -- NAS3-25606

The Advanced Communications Technology Satellite (ACTS) and the associated, dispersed 30/20 GHz ground terminals now under development are the prototypes and precursors of future 30/20 GHz SATCOM systems. In order to fully exploit these evolving large-scale communications capabilities, it is imperative that Earth-station 30 GHz transmitters be simple, reliable, inexpensive, and with sufficient RF power, typically 8-16 W, for time-domain, multiple-access (TDMA) burst rates of 13.75-27.5 Mbps. Since the average burst duty cycle for the up-link is about 0.025, a pulsed, solid-state power amplifier (SSPA) built from high-peak-power IMPATTs might be developed into a simple, low-cost, 30-GHz transmitter.

Phase I will investigate the suitability of a pulsed IMPATT amplifier, including its intrapulse, gain-phase and transient characteristics, to handle TDMA traffic without degradation. A pulsed 30 GHZ IMPATT SSPA design will be generated which could be the basis of a Phase II hardware development program.

Potential Commercial Applications: This development could provide low-cost, high-performance, pulsed 30 GHz IMPATT SSPAs suitable for the entire gamut of next-generation, commercial 30/20 GHz terminals.

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*** 221**
88-1-14.09-2550
High T_c Films for Microwave Applications
CVC Products Inc.
PO Box 1886
Rochester, NY 14603
James Argana (716-454-8255)
JPL -- NAS7-1045

Building on its collaboration with the University of Rochester, the company intends to develop thin-film, high-T_c superconductors, such as $YBa_2Cu_3O_7$, for application to passive microwave circuits. The primary technique will be rf magnetron sputtering of reacted oxides from a large target for uniform deposition across two-inch substrates. This process has produced high-quality superconducting films following high-temperature annealing and, more recently, at a medium-temperature (630 °C). The devices will employ a reaction-barrier layer before depositing the high-T_c films on substrates such as Al_2O_3, Si, and GaAs; thin-film silver pads for low-loss contacts; and a protective, sputter-deposited dielectric overlayer. The films will be patterned into transmission lines and strip-line resonators using standard photolithography and etching. The Q of the resonators (and thus rf surface resistance) will be measured at frequencies up to 20 GHz, over a wide range of temperature, and compared to that of conventional copper lines. These microwave properties will be corrected with dc electrical measurements and materials properties.

Potential Commercial Applications: Reliable high-T_c superconducting films for microwave circuit elements, MMIC's, antennas, and high-Q resonators could serve in communications systems and radar in space and ground-based systems.

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15 MATERIALS PROCESSING, MICROGRAVITY, AND COMMERCIAL APPLICATIONS IN SPACE

*** 222**
88-1-15.01-0333
Magnetic Float Zone Microgravity Crystal Growth: Application to Silicon Carbide
Scientific Research Associates Inc.
PO Box 1058
Glastonbury, CT 06033
Y. T. Chan (203-659-0333)
MSFC -- NAS8-38030

By applying an axial DC magnetic field to a floating zone crystal growth process it may be possible to improve the quality of materials grown by this technique under microgravity conditions. The purpose of the magnetic field is to suppress the undesirable surface-tension-driven convection caused by temperature and dopant variations. In Phase I, the concept will be verified through numerical magnetohydrodynamic and heat transfer simulations of a realistic floating zone system. A parametric study will be performed in

Phase II to compile a knowledge base for designing a commercial apparatus with automated feedback control of the growing process. The entire system will be self-contained and require minimum human control. Realistic parameters will be used for simulating growth of titanium carbide crystals for use as substrates in the epitaxial growth of silicon carbide. The design studies of Phase II would be carried out for both Earth gravity and microgravity conditions, and an orbital reactor would also be designed.

Potential Commercial Applications: Results of this work could meet the need of the semiconductor industry for high quality crystals of various compounds.

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* **223**
88-1-15.01-5544
Growth of III-V Ternary Crystals by Liquid-Phase Electro-Epitaxy
Microgravity Research Associates
PO Box 10505
Midland, TX 79702
Tadeusz Bryskiewicz (915-684-5544)
LeRC -- NAS3-25627

Through sponsorship of four years of research at MIT on growing of high-quality crystals using liquid phase electroepitaxy (LPEE), the company can produce bulk GaAs crystals approaching 25 mm in diameter and 5 mm in thickness with a purity, structural perfection, homogeneity, and luminescence efficiency far superior to melt grown material. This process will be extended to grow high-efficiency (in terms of luminescence intensity), bulk ternary crystals that are compositionally uniform with epitaxial quality and approaching 25 mm in diameter and 5 mm in thickness. These crystals, not achievable by other growth techniques, would be a new class of the highest quality substrate materials for optoelectronic and microwave devices.

Phase I will study which ternary compounds are in greatest demand and what characteristics are desired for devices. This will set priorities and pinpoint the necessary resources. Phase II will see the research, development, and production of the crystal leading to Phase III commercial deployment.

Potential Commercial Applications: Ternary III-V substrate materials can be used in fabricating photodetectors, light-emitting diodes, semiconductor lasers, cascade solar cells, phototransistors, bipolar transistors, and high-frequency FETs and HEMTs.

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224
88-1-15.01-5800
Physical Vapor Transport and Crystal Growth of Tellurium: A Novel Acousto-Optic Material
Brimrose Corporation of America
5020 Campbell Blvd., Bldg. 1
Baltimore, MD 21236
S. B. Trivedi (301-529-5800)
LeRC -- NAS3-25613

Improved understanding of vapor transport and crystal growth in microgravity requires systematic design and optimization of ground-based experiments. Past experimental work on compounds (i.e. HgI_2, GeSe-GeI_4, GeSe-Xe) has involved chemical complexities in vapor and solid phases that caused difficulties in understanding the results. A simple, scientifically strong experimental system using tellurium as a model material will be defined to overcome these difficulties. Tellurium, a group VI element, is chemically simple and is free of complex vapor-phase reactions. It has a relatively low melting point (450 °C) and a vapor pressure high enough for transport and growth by sublimation. Applications exist for tellurium crystals in 10.6-μm laser beam modulation and steering.

The study will address the effects on crystal growth of ampoule size and geometry, orientation with respect to gravity and temperature gradient, and vapor transport rates. Experimental rates will be compared with theoretical models. Vapor-grown crystals will be characterized with respect to structural and electrical properties.

Potential Commercial Applications: This work could help grow crystals of good quality and reasonable size under ground based conditions. Moreover, good quality tellurium single crystals have a potential as novel acousto-optic material.

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* **225**
88-1-15.01-6684
Microgravity Sonic Pump Levitator Furnace
Orbital Technologies Corp.
402 Gammon Place, #10
Madison, WI 53719
Eric E. Rice (608-833-1992)
MSFC -- NAS8-38042

This project will advance the state-of-the-art in microgravity, containerless materials processing for production and research. The microgravity sonic pump furnace (MSPF) concept is based upon the sonic pump levitator principle that provides rapid position control at modest accelerations for samples up to 4 cm in diameter while the sample is being heated and melted under controlled conditions. Specific sensor systems will be used to monitor the state condition of the sample as it undergoes processing. The MSPF systems can be flown on the KC-135 or Lear aircraft, the space shuttle, the Space Station, a commercially developed space facility, or other future systems. The Phase I effort will review the applicability of the technology in microgravity research, will improve the theory and engineering analysis models, and develop a preliminary design concept.

Potential Commercial Applications: This project may provide microgravity equipment which can assist scientific research and space commercial production

of new electronic materials, metal alloys, glasses, ceramics, and electro-optical materials.

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* **226**
88-1-15.02-0200
Numerical Simulation of Crystal Growth Processes
Fluid Dynamics International Inc.
1600 Orrington Avenue
Evanston, IL 60201
Simon Rosenblat (312-491-0200)
LeRC -- NAS3-25612

A computer software program will be developed that will enable the numerical simulation of crystal growth from a melt, including heat and mass transfer, transport of solute, tracking of the solidification front, and meniscus effects. The program will be based on the finite-element method and will allow both steady-state and transient simulations. The work will comprise development, testing, and implementation of new capabilities related to the existing commercial, finite-element program, FIDAP. Aspects of the crystal growth process under conditions of microgravity will be specially emphasized.

Potential Commercial Applications: The results of this project could permit numerical simulation of float-zone, Czochralski, and Bridgman crystal growth processes.

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* **227**
88-1-15.03-5777
Chemical Vapor Deposition Fluid Flow Simulation Modelling Tool
Nektonics Inc.
400 Fifth Avenue
Waltham, MA 02154
Edward T. Bullister (617-290-5750)
LaRC -- NAS1-18831

In order to improve the simulation of chemical vapor deposition processes in closed and open systems, this project will enhance the commercial NEKTON code, which is used to solve the unsteady three-dimensional, incompressible Navier-Stokes equations. This program employs user-friendly menus and graphics-based pre- and post-processors.

Phase I will extend NEKTON to provide: simultaneous solutions of three-dimensional unsteady momentum, energy, and multi-species conservation equations in dilute systems; temporal tracking of reacting species in the gas and on the reacting surfaces; and a coupled solution of conduction-convection equations in complex three-dimensional geometries with rotating boundaries. Phase II will develop solutions of the transport equations in non-dilute systems and include thermal diffusion in the gas and time-dependent gravitational acceleration with complex surface reaction mechanisms in three-dimensional geometries with multi-reacting surfaces.

Potential Commercial Applications: The process could be applied to growth of different layers for digital, integrated circuits, in compound semi-conductor hetero-structures and for structured, layered materials.

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228
88-1-15.04-8200
Low-Cost Space Power Generation
Chronos Research Laboratories
41866 Sorrento Valley Blvd., Suite H
San Diego, CA 92121
Randall B. Olsen (619-455-8200)
LeRC -- NAS3-25604

Low-cost space power is a key technology for the exploration and commercialization of space. Pyroelectric conversion is likely to be dominant in space electrical power generation for two reasons: its low mass will make it the least expensive to place in orbit, and the materials and system costs of pyroelectric converters are expected to be far lower than photovoltaic, nuclear, and chemical approaches. Electric propulsion powered by ultra-lightweight, pyroelectric converters may also make higher orbits economically accessible because of the low mass of the power plant, its radiation resistance, and its high-voltage output, which matches well with the requirements of the propulsion unit.

The objective of the Phase I effort is to determine the long-term stability of the characteristics of a pyroelectric polymer which has recently been shown to have substantial energy conversion capability. The properties of the material will be followed for extended time periods as it is subjected to the thermal and electrical cycling conditions which will exist in pyroelectric energy converters.

Potential Commercial Applications: On Earth, pyroelectric converters will operate on industrial waste heat to produce low-cost electrical power.

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Appendix A

DESCRIPTION OF THE SBIR PROGRAM

The Small Business Innovation Research program was instituted in 1982 by Public Law 97-219 and reauthorized through Fiscal Year 1993 by the enactment of Public Law 99-443 in 1986. Implementation of the program follows policy directives issued by the Small Business Administration (SBA). Eligibility is limited to US-owned companies operating in the US having fewer than 500 employees at the time a contract is awarded.

Purposes of the Program: The purposes of the Small Business Innovation Research program include stimulating US technological innovation in the private sector, strengthening the role of small businesses in meeting Federal research and development needs, increasing the commercial application of Federally supported research results, and fostering and encouraging participation by minority and disadvantaged persons in technological innovation. Achievement of these purposes is accomplished through actions taken by the agency to meet its own particular R&D needs within the program framework established by the laws and the SBA policy directive guidelines.

SBIR Program Phases: As specified by the enabling legislation, SBIR is a three-phase R&D program. For Phase I, the objectives are to establish the feasibility and merit of an innovative scientific or technical concept proposed by a small business responding to a need or opportunity delineated by the agency in an annual program solicitation. Contracts for Phase I are awarded through a competitive selection process based upon the evaluation of Phase I proposals submitted in response to an annual program solicitation.

Phase II of SBIR is the principal research and development effort, having as its purpose 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 into Phase II. The selection of Phase II awards considers the scientific and technical merit and feasibility evidenced by the first phase, the expected value of the research to the agency, and the competence of the firm to conduct Phase II. In addition, for Phase II proposals considered to have essentially equivalent scientific merit and feasibility, special consideration is given to those for which valid non-federal funding commitments have been obtained for Phase III activities.

In Phase III, the small business can pursue commercial applications of the results of the SBIR-funded research and research and development (R/R&D). Phase III for commercial purposes is strongly encouraged by NASA as a major SBIR objective. Phase III may also take the form of follow-on R/R&D or production contracts with NASA or other federal agencies for products and processes intended for use by the United States Government; however, such Phase III activities cannot be supported by the SBIR program funding set-aside.

Phase I and II Funding Levels: NASA funding for SBIR projects is in keeping with guidelines for the SBIR program issued by the Small Business Administration. Phase I contracts are generally limited to six months in duration and $50,000, while contracts for Phase II, the major R&D effort, are normally limited to two years' duration and funding of not more than $500,000. NASA may make justifiable exceptions.

Proposal Evaluation and Award Selection: Evaluations of both Phase I and II proposals follow SBA Policy guidelines and include technical merit and innovativeness, NASA R&D needs and priorities, program balance, and company capabilities. There are no quotas for specific technical areas. For Phase I, proposed cost within the stated cost guideline is not an evaluation or selection criterion and appropriate for the proposed activity. For Phase II, the Phase I results are a major factor and cost is an important consideration. And as noted above, for Phase II proposals of essentially equivalent merit, special consideration is given to those which include valid non-federal capital commitments for Phase III activities, particularly for pursuing commercial applications. Evaluators include NASA technical staff members at the field centers responsible for the Subtopics and the NASA Headquarters program officials. NASA at its discretion may also use outside evaluators.

Program History: The NASA SBIR program began in 1983 with the issuance of the first of its annual program solicitations. Support for this program is shown in Table A-1, which displays the annual R&D funding set-aside (which progressively increased to the present 1.25 percent level) for the NASA SBIR program. Table A-2 shows the

number of Phase I proposals received each program year and the number of resulting awards and funding for Phase I contracts. This table also presents the number of Phase II proposals that were submitted from each group of Phase I projects and the numbers selected for award and the total value of the Phase II contracts for each program year. (A program year includes all Phase I and Phase II projects resulting from an annual Program Solicitation.) During the first five complete Program Years (1983 through 1987) and Phase I of the 1988 and 1989 programs, $244 million was obligated or committed for 1231 Phase I and 398 Phase II awards. Recently, NASA announced the selection of 112 of the 1988 Phase I projects for negotiations leading to Phase II SBIR contracts. On the average, approximately 16 percent of NASA's SBIR funds have been used for Phase I projects and 84 percent for Phase II in each program year.

Small businesses have responded vigorously to the opportunities presented by the SBIR program. The number of Phase I proposals grew from 977 in 1983 to 2,141 in 1989. The number of Phase I awards selected has been limited each year not by the number of acceptable proposals, but by the funds available and the desire that at least half of the Phase I projects proceed into Phase II. Awards have been made to 650 firms in 42 states, the District of Columbia and Puerto Rico. The numbers of Phase I and Phase II awards made within each state are shown on Exhibit A-1. Approximately 18 percent of the firms submitting proposals have received Phase I awards, and about 48 percent of those firms have received Phase II continuations.

TABLE A-1

NASA SBIR FISCAL YEAR FUNDING

	FISCAL YEAR 1983	FISCAL YEAR 1984	FISCAL YEAR 1985	FISCAL YEAR 1986	FISCAL YEAR 1987	FISCAL YEAR 1988	FISCAL YEAR 1989
NASA R&D BUDGET - $M	2473.00	2205.00	2425.00	2619.00	3128.00	3270.00	4166.00
% R&D BUDGET FOR SBIR	0.20	0.60	1.00	1.25	1.25	1.25	1.25
NASA SBIR BUDGET - $M	4.94	13.23	24.25	32.74	38.92	40.87	52.97
CUMULATIVE TOTALS - $M	4.94	18.17	42.42	75.16	114.08	154.95	207.92

TABLE A-2

NASA SBIR PROGRAM AWARD STATISTICS

PROGRAM SOLICITATION YEAR	PHASE I			PHASE II			PHASE I & II
	PROPOSALS	AWARDS	TOTAL FUNDING $M	PROPOSALS	AWARDS	TOTAL FUNDING $M	TOTAL PROGRAM FUNDING $M
1983	977	102	5.0	92	58	24.0	29.0
1984	919	127	6.3	113	71	32.5	38.8
1985	1164	150	7.4	129	84	39.4	46.8
1986	1628	172	8.5	154	85	39.6	48.1
1987	1826	204	10.0	179	100	47.9	57.9
1988	2379	228	11.2	204	112	53.7 (1)	64.9 (1)
1989	2142	251	12.4 (1)	NA	NA	NA	NA
TOTALS TO DATE	11035	1234	60.8	871	510	237.1 (1)	285.5 (1) (6 YEARS)

NOTE: (1) ESTIMATED

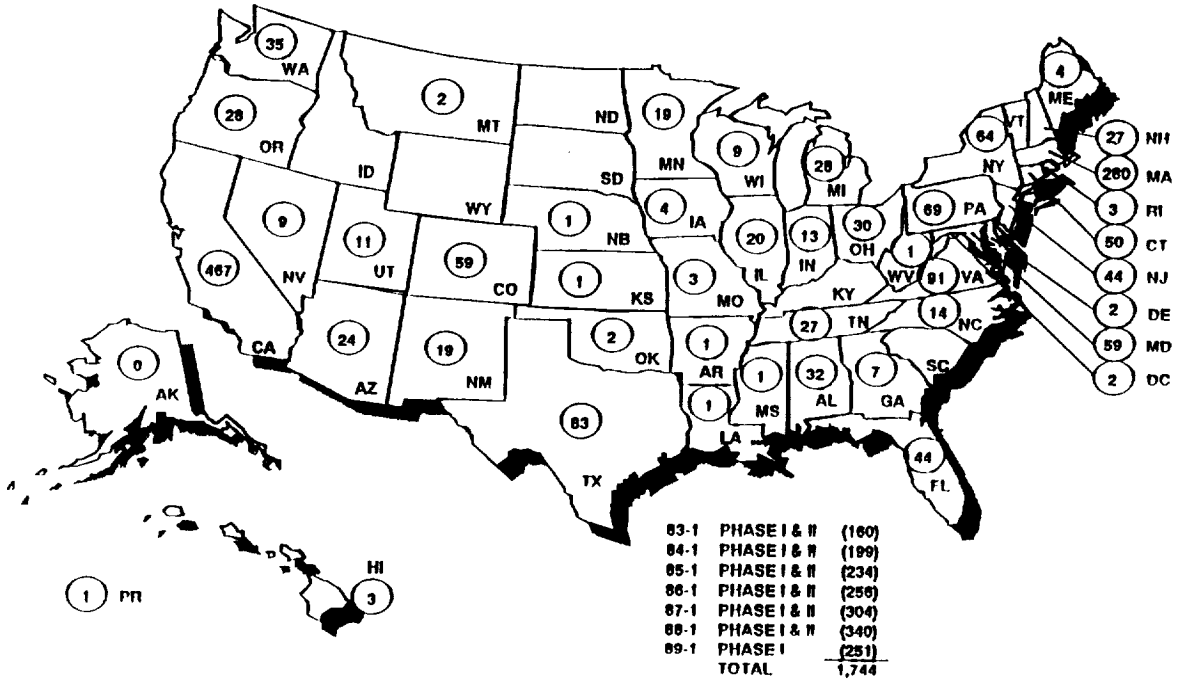
TABLE A-3

NASA SBIR AWARDS
DISTRIBUTION BY NASA FIELD CENTER

FIELD CENTER	1989 PHASE I	TOTAL PHASE I	TOTAL PHASE II	TOTAL PHASE I & II
AMES RESEARCH CENTER	27	150	65	215
GODDARD SPACE FLIGHT CENTER	38	168	73	241
JET PROPULSION LABORATORY	25	131	55	186
JOHNSON SPACE CENTER	37	172	67	239
KENNEDY SPACE CENTER	11	58	23	81
LANGLEY RESEARCH CENTER	35	187	77	264
LEWIS RESEARCH CENTER	37	187	73	260
MARSHALL SPACE FLIGHT CENTER	36	169	74	243
STENNIS SPACE CENTER	5	12	3	15
TOTALS	251	1,234	510	1,744

EXHIBIT A-1

NASA SBIR AWARD DISTRIBUTION BY STATES



Appendix B

1988 TOPICS AND SUBTOPICS

01 Aeronautical Propulsion and Power
- 01.01 Internal Fluid Mechanics for Propulsion Systems
- 01.02 Propulsion System Components
- 01.03 Propulsion System Instrumentation, Sensors and Controls
- 01.04 Hypersonic Propulsion Technology
- 01.05 Novel Propulsion Concepts
- 01.06 Structural Computational Methods for Propulsion Systems

02 Aerodynamics and Acoustics
- 02.01 Computational Fluid Dynamics
- 02.02 Experimental Fluid Dynamics
- 02.03 Viscous Flows
- 02.04 Theoretical Aerodynamics
- 02.05 Hypersonic Aerothermodynamics
- 02.06 Plume Effects
- 02.07 Rarefied Gas Dynamics
- 02.08 Configurational Aerodynamics Including Vortices
- 02.09 Rotor Aerodynamics and Dynamics
- 02.10 Prediction Methods and Concepts for Powered-Lift Vehicle Aerodynamics
- 02.11 Wind Tunnel Instrumentation
- 02.12 Aircraft Noise

03 Aircraft Systems, Subsystems, and Operations
- 03.01 Icing and Ice Protection Systems
- 03.02 Aircraft Flight Environment
- 03.03 Control Concepts for Fixed Wing Aircraft
- 03.04 Fully Automatic Guidance for Rotorcraft
- 03.05 Aircraft Flight Testing Techniques
- 03.06 Flight Research Sensors and Instrumentation
- 03.07 Hypersonic Flight Systems Technology
- 03.08 Multi-Disciplinary Analysis Tools and Techniques for Hypersonic Vehicles
- 03.09 Expert Systems for Aerospace Applications
- 03.10 Computer-Aided Development, Testing, and Verification of Flight Critical Systems
- 03.11 Aeronautical Human Factors and Flight Management Systems

04 Materials and Structures
- 04.01 Structural Composite Materials for Propulsion Systems
- 04.02 High Temperature Structural Composites Methodology
- 04.03 Structural Composite Materials for Non-Propulsion Applications
- 04.04 Light Alloy Metallics for Airframe Structures
- 04.05 Spacecraft Structural Concepts and Fabrication Techniques
- 04.06 Special-Purpose Materials for Space Flight Applications
- 04.07 Environmental Coatings, Lubricants, and Protective Systems for Spacecraft
- 04.08 Organic Polymeric Materials for Large, Nonlinear Optical Susceptibilities
- 04.09 Non-Destructive Evaluation for Characterizing Material Properties
- 04.10 Superconducting Materials Fabrication and Characterization
- 04.11 Lunar Materials Utilization
- 04.12 Advanced Materials and Processing Concepts

05 Teleoperators and Robotics
- 05.01 Telerobotic System Planning and Design
- 05.02 Telerobotic Systems Software Development
- 05.03 Telerobotic Electromechanical Systems
- 05.04 Robotic Adaptive Grasping Systems
- 05.05 Artificial Intelligence for Space Station Applications

06 Computer Sciences and Applications
- 06.01 Engineering Computer Science
- 06.02 Automated Software Development and Maintenance
- 06.03 Reliable Software Development
- 06.04 Knowledge-Based Systems Technologies for Aerospace Applications
- 06.05 Design Knowledge Capture
- 06.06 Software Systems for Mission Planning and Flight Control
- 06.07 Computer Sciences Advances in Suppport of Computational Physics
- 06.08 Multiprocessor System Technology

07 Information Systems and Data Handling
- 07.01 Focal-Plane Image Processing
- 07.02 Image Analysis Techniques
- 07.03 Statistics of Spatial Patterns and Spatial Interaction Processes
- 07.04 Spatial Data Management and Geographic Information Systems (GIS) Technology Development
- 07.05 Signal and Information Processing
- 07.06 Information Processing Technology and Integrated Data Systems
- 07.07 Spacecraft Operations and Data Management
- 07.08 Ground-Based Data Management Systems
- 07.09 Spacecraft Ground System Data Design and Management
- 07.10 Heterogeneous Distributed Database Management
- 07.11 Management Information Communications
- 07.12 Search for Extraterrestrial Intelligence

08 Instrumentation and Sensors
- 08.01 Instruments for Sensing Electromagnetic Radiation
- 08.02 Earth Atmosphere Sensing from Space
- 08.03 Low-Cost High Resolution Remote Sensing Instrumentation for Earth Sciences
- 08.04 Sensors for Atmospheric Science
- 08.05 Instruments and Systems for Atmospheric Observations
- 08.06 Atmospheric LIDAR Remote Sensing

08.07 Tunable Solid State Lasers Detectors and LIDAR Subsystems
08.08 Instruments for Geological Research
08.09 Oceanographic Instruments and Software
08.10 Flight Instrument Technology for Exobiology
08.11 Instrumentation for the Study of Planetary Atmospheres
08.12 Infrared Technology for Astronomical Applications
08.13 Detector and Detector Arrays
08.14 Sensor Cooling for 65-80 Kelvin
08.15 Cryogenic Fluid Instrumentation for Orbiting Spacecraft
08.16 Submillimeter Antennas, Radiometers and Spectrometers
08.17 Optical Components
08.18 Optical Systems
08.19 Optical Properties of Boundary Layer Flow Across a Cavity
08.20 Focal Plane Array Processing for Position Determinations
08.21 Instruments for Particle Collection and Processing
08.22 Environmental Measurements and Analyses in Manned Space Missions
08.23 Behavior and Effects of Contamination in Space
08.24 Leak Detection for Spacecraft Functional Systems
08.25 Non-Invasive Monitoring of Growth Parameters on a Hanging Protein Drop

09 Spacecraft Systems and Subsystems
09.01 Control of Large Space Structures
09.02 Space Construction and Maintenance Tools and Techniques
09.03 Space Station Crew Workstation Displays and Controls
09.04 Space Station Shell Leak Detection and Assessment System
09.05 Manned Spacecraft and Planetary Base Thermal Management Systems
09.06 Spacecraft and Propulsion System Thermal Management Systems
09.07 Thermal Control for Unmanned Space Applications
09.08 STS Power Control and Distribution Subsystems
09.09 STS and Space Station Robotic Tracking Systems
09.10 Guidance Navigation and Control of Advanced STS
09.11 Tether Applications in Space
09.12 A Low Cost, CCD Solid State Star Tracker
09.13 Technologies for Scientific Balloons
09.14 High Temperature Superconductor Applications for Space

10 Space Power
10.01 Spacecraft Electrical Power and Energy Systems
10.02 High Energy Density and Long Life Batteries
10.03 Corona Detection at 20 KHz Applied Voltage
10.04 Photovoltaic Laser Energy Converters
10.05 Space Power Systems Automation
10.06 Power Transmission and Propulsion Applications of High-Temperature Superconductivity

11 Space Propulsion
11.01 Solid Rocket Motor Technology
11.02 Solid Rocket Performance and Internal Ballistics
11.03 Liquid Rocket Engine Combustion Processes
11.04 Liquid Engine Internal Flow Dynamics
11.05 Long-Life, High-Performance, Small Chemical Rockets
11.06 Space Basing of Rocket Engines

12 Human Habitability and Biology in Space
12.01 Medical Sciences for Manned Space Programs
12.02 Waste Stabilization, Reclamation and Monitoring for Space Station
12.03 Advanced Mission Environmental Control and Life Support Systems
12.04 Bioregenerative Life Support Systems
12.05 Human Factors for Space Crews
12.06 Intravehicular Systems for Space Crews
12.07 Extravehicular Activity (EVA)
12.08 Life Sciences Spaceflight Hardware Development
12.09 Physio-Chemical Life Support Systems
12.10 Biological Sciences Operations

13 Quality Assurance, Safety, and Check-out for Ground and Space Operations
13.01 Ground Operations Instrumentation
13.02 Propellant Handling
13.03 Launch and Ground Processing Weather
13.04 Non-Destructive Evaluation of Thermal Protective Tile Bonding
13.05 Use of Heat Pipes for Reheating of Conditioned Air
13.06 Multi-Position Portable Liquid Air Dewar
13.07 Large Magnitude Force Torque Sensing
13.08 Space Component Test Facility Devices

14 Satellite and Space Systems Communications
14.01 Communications for Manned Space Systems
14.02 Free-Space Laser Communications
14.03 Millimeter Wave Deep Space Communications Systems
14.04 Spacecraft Telecommunication Subsystems
14.05 Advanced Communications Satellite Systems
14.06 Monolithic Distress Beacon Technology
14.07 Emergency Locator Transmitter Batteries and Crash Sensors
14.08 Low-Cost Ka-Band Ground Terminals
14.09 Communications Application for Superconducting Materials

15 Materials Processing, Microgravity, and Commercial Applications in Space
15.01 Materials Processing in Space
15.02 Microgravity Science Technology and Engineering Experiments
15.03 Chemical Vapor Deposition Analysis and Modeling Tools
15.04 Space Power Generation, Propulsion, and Related Technologies
15.05 Optical Materials and Components
15.06 Life Science Commercial Research and Applications in Space

Appendix C

INDEX OF PROJECTS BY STATE

Appendix D

INDEX OF PARTICIPATING COMPANIES

Charles River Analytics Inc.
Cambridge, MA 02138
044 - EEG-Based Metric for Flight Deck Workload Assessment

Charles Systems Corporation
Ann Arbor, MI 48104
* 150 - Development of a Compact, Six-Degree-of-Freedom, Force-Reflecting Hand Controller with Cuing and Multiple Operating Modes

Chemical Dynamics Corporation
Upper Marlboro, MD 20772
016 - Mechanisms of Energy Accommodation on Catalytic Surfaces
017 - Temperature-Dependent Energy Transfer Recombination on Surfaces

Chronos Research Laboratories
San Diego, CA 92121
228 - Low-Cost Space Power Generation

Cleveland Crystals, Inc.
Cleveland, OH 44110
127 - Tunable BBO and $AgGaSe_2$ Optical Parametric Oscillator System

Computational Mechanics Company
Austin, TX 78705
* 011 - Pre- and Post-processing Techniques for Determining Goodness of Computational Meshes
* 022 - A New Approach for Solving the Navier-Stokes Equations on Unstructured Grids Based on Adaptive Methods and Operator Splitting

Continuum Dynamics, Inc.
Princeton, NJ 08543
* 031 - A Liquid Water Content Meter
* 009 - New Computational Method for Aeroelastic Problems in Turbomachines

Creare Inc.
Hanover, NH 03755
* 132 - A Thermally Effective Regenerator for Low-Temperature Cryocoolers

Cree Research, Inc.
Durham, NC 27713
* 005 - Silicon Carbide MOSFETs for High-Temperature, Small-Signal Amplifiers

CVC Products, Inc.
Rochester, NY 14603
* 221 - High T_c Films for Microwave Applications

Daedalus Enterprises, Inc.
Ann Arbor, MI 48106
* 039 - Interferometric Imaging and Frequency Estimation of Surface Vibration Patterns
126 - Feasibility of Modifying a Thermal Scanner to Measure Lava Flow Characteristics

DCL-Direct Current-Light
Lawndale, CA 90260
193 - Applications of an Automatic Inventory and Personnel Tracking System

Deacon Research
Palo Alto, CA 94304
* 141 - Technique to Evaluate UV-Induced Degradation of Space Optics

Defense Research Technologies, Inc.
Rockville, MD 20850
028 - Acousto-Fluidic Noise Generators for Aircraft Component Structure Testing

Detector Technology, Inc.
Brookfield, MA 01506
136 - Manufacturing Large-Area, High-Gain Microchannel Plates for Military and Commercial Applications

Digital Signal Corporation
Springfield, VA 22151
196 - A Multiple-Read SAW Tag Inventory System Development

Displaytech, Inc.
Boulder, CO 80301
151 - Multicolor Flat-Panel Display using Tunable Birefringence Filters

DSET Laboratories, Inc.
Phoenix, AZ 85029
050 - Thermal Control Coatings for Composite Structures

ECON, Inc.
San Jose, CA 95117
093 - Applied Research of KBS Technologies for Advanced Decision Support Systems

EIC Laboratories, Inc.
Norwood, MA 02062
* 171 - Long Cycle Life Rechargeable Lithium Batteries
179 - High Temperature Superconducting Composites
* 203 - Real-time Hydrazine Monitoring with Surface Enhanced Raman Spectroscopy (SERS)

Eidetics International, Inc.
Torrance, CA 90505
* 023 - Aerodynamic Control of NASP-Type Vehicles Through Vortex Manipulation
033 - Agility Management System for High-Performance Aircraft

Electro Magnetic Applications, Inc.
Denver, CO 80226-0263
206 - Investigation of the Triggering of Lightning by Launch Vehicles During Ascent

Electro-Optek Corporation
Torrance, CA 90505
* 135 - Cryogenically-Cooled InSb JFET
* 172 - Fabrication of Photovoltaic Laser Energy Converter by MBE

Electronic Associates, Inc.
West Long Branch, NJ 07764
* 076 - A Parallel Processor for Simulating Manipulators and Other Mechanical Systems

Emerson & Stern Associates, Inc.
San Diego, CA 92121
043 - Voice I/O for Flight Management Systems

Engineering Research & Consulting, Inc.
Tullahoma, TN 37388
* 041 - Intelligent Hypertext Systems for Aerospace Knowledge Representation

Epitaxx, Incorporated
Princeton, NJ 08540
113 - High-Gain Avalanche Photodiode Arrays for Long-Wavelength Applications

Excel Technology, Inc.
Bohemia, NY 11716
125 - SIS Detector in the 100-Micron-Wavelength Region Fabricated with Thin Film of High-Tc, Bi-Ca-Sr-Cu-O Superconductor

Exfluor Research Corporation
Austin, TX 78713-7807
054 - Evaluation of Several New Perfluoropolyether Copolymers Containing Tetrafluoroethylene Oxide

Expert-Ease Systems
Belmont, CA 94002
098 - Development of a System Library Facility for Parallel Computers

EXPORTech Company, Inc.
New Kensington, PA 15068
064 - Magnetic Beneficiation of Lunar Soil

Extrude Hone Corporation
Irwin, PA 15642
* 082 - Robotic Adaptive Grasping with a Capacitance-Array Tactile Sensing System

Fluid Dynamics International Inc.
Evanston, IL 60201
* 226 - Numerical Simulation of Crystal Growth Processes

Foster-Miller, Inc.
Waltham, MA 02254
* 048 - Innovative Prepregging for High-Temperature Thermoplastics
152 - A Lightweight Non-Metallic Heat Pipe Radiator
* 153 - Binary Mixtures for Spacecraft Heat Transport
168 - Improved Thermal Energy Storage System for Advanced Solar-Dynamic, Space-Power Generation

Frederick A. Costello, Inc.
Herndon, VA 22071
156 - Novel Cryocooler Regenerator Designs
* 157 - Computing Radiant Interchange among Real Surfaces

FWG Associates, Inc.
Tullahoma, TN 37388
* 116 - Rain-Rate Instrument for Deployment at Sea

General Digital Industries, Inc.
Huntsville, AL 35806
* 084 - An Automated Wire Guide for Robotic Welding Applications

General Pneumatics Corp., Western Research Center
Scottsdale, AZ 85260
131 - Joule-Thomson Cryo-Refrigerator for Spacecraft Sensors and Stored Cryogens

Geo-Centers, Inc.
Newton Centre, MA 02159
* 006 - Fast Optical Switch for Multi-Mode-Fiber-Optic-Based Control Systems
079 - Composite, Six-Axis Force Sensor with Embedded Optical Sensors
165 - Fiber-Optic Sensor Technology for High Altitude Balloons
* 201 - Optrode Development for Environmental pH Monitoring

Geoscience Ltd.
Solana Beach, CA 92075
188 - A Whole Body Calorimeter for Space Station Astronauts

Giner, Inc.
Waltham, MA 02254-9147
170 - Cathode Catalyst Support Materials for High Temperature Alkaline Fuel Cells

Holometrix, Inc. (Electro-Optics Division)
Cambridge, MA 02139
160 - A High-Precision Sun-Tolerant LIDAR

Holz Industries, Inc.
San Diego, CA 92123
* 217 - Quartz/Fused Silica Chip Carriers

HSA, Inc.
Sugar Land, TX 77479
* 111 - An Extensible Shell for Information Access in Heterogeneous Environments

Huntsville Sciences Corporation
Huntsville, AL 35805
183 - Finite Element Code for Combustion Analysis of Advanced Propulsion Systems

Hydrogen Consultants, Inc.
Littleton, CO 80125
138 - Reversible Oxide Chemical Compressor for Sensor Cryocooling

Information & Control Systems, Incorporated
Hampton, VA 23666
* 032 - A Stochastic, Optimal, Feedforward and Feedback Control Methodology for Super-Agility

Infrared Laboratories, Inc.
Tucson, AZ 85719
* 114 - Silicon Bolometer Arrays for Helium-3 Detector System

Innovative Dynamics
Ithaca, NY 14850-1296
* 029 - Aircraft Icing Performance Measurement System
* 035 - Experimental Investigation on the Detection of Transitioning Flow-Fields

Innovative Research, Inc.
Denver, CO 80220
086 - An Automatic Scheduling Assistant for the NASA Space Station

Integrated Parallel Technology, Inc.
Campbell, CA 95009
* 099 - VME Rollback Hardware Modules for Time-Warp Microprocessor Systems

Integrated Systems, Inc.
Santa Clara, CA 95054
040 - Numerical Optimization of Single-Stage-to-Orbit Configuration with Inequality Constraints
* 149 - Robust Adaptive Control of Large Space Structures

IntelliCorp Inc.
Mountain View, CA 94040-2216
* 087 - Compiling Knowledge-Based Systems Specified in KEE to Ada

Intelligent Automation Systems, Inc.
Cambridge, MA 02141
* 083 - Sensor-Based, Whole-Arm Manipulation for Adaptive Grasping

Intelligent Recognition Systems
Canoga Park, CA 91303
073 - A Perception System for Object Recognition, Acquisition, and Tracking in Cluttered Environments

Ionwerks
Houston, TX 77030
061 - Atomic Oxygen Source for Superconducting Thin-Film Fabrication

KMS Fusion, Inc.
Ann Arbor, MI 48106-1567
074 - A Single-View, Three-Dimensional Object Recognition System

Kopin Corporation
Taunton, MA 02780
* 169 - Feasibility of a Technique for Fabrication of Low-Cost Epitaxial Indium Phosphide Solar Cells

Laser Data Technology, Inc.
St. Louis, MO 63132
* 215 - Multi-Access Free-Space Laser Communication System Design

Laser Power Corporation
San Diego, CA 92130
* 143 - Digital Image Profilers for Detecting Faint Sources which have Bright Companions

LaserGenics Corporation
San Jose, CA 95161-1330
026 - Very High Temperature Fiber Sensors
060 - Superconducting Fibers of Bi(Pb)-Ca-Sr-Cu-O

Lightwave Electronics Corporation
Mountain View, CA 94043
* 123 - Tunable, Single-Frequency, Solid-State Laser Transmitter
214 - Coherent Communication Link Using Diode-pumped Lasers

LinCom Corporation
Houston, TX 77058
* 095 - SimTool - An Integrated Graphics and On-Orbit Vehicle Dynamics Simulation Tool

LNR Communications, Inc.
Hauppauge, NY 11788
220 - Pulsed Solid State Power Amplifiers for 30/20 GHz Satcom Terminal Up-Link Transmitter

Magnetic Concepts
Silver Spring, MD 20901
177 - Electromagnetic Insulators

Mainstream Engineering Corporation
Rockledge, FL 32955
* 158 - Modular Chemical-Mechanical Heat Pump for Spacecraft Thermal Bus Applications
* 205 - Improved System for SCAPE Suit Heating

Martingale Research Corporation
Allen, TX 75002
* 096 - A Cognitive Neurocomputer for Mission Planning and Control

Maxdem Inc.
Pasadena, CA 91105
049 - Development of Thermally Stable, Low Dielectric Films for Aerospace Applications
* 057 - Non-linear Optical properties of Polyphenylenes

Mayflower Communications Company, Inc.
Reading, MA 01867
* 162 - Autonomous Integrated GPS/INS Navigation Experiment for OMV

MESO, Inc.
Hampton, VA 23666-1325
* 207 - A Mesoscale Statistical Thunderstorm Prediction System

MetroLaser
Irvine, CA 92714-6428
181 - Liquid Rocket Atomization, an Innovative Numerical and Experimental Simulation

Micro Craft, Inc.:
Tullahoma, TN 37388
204 - An Improved Quick Disconnect for Aerospace Fluid Systems

Micro-G Research, Inc.
Philadelphia, PA 19104-3323
199 - Variable-G Facility for LIFESAT

Microgravity Research Associates
Midland, TX 79702
* 223 - Growth of III-V Ternary Crystals by Liquid-Phase Electro-Epitaxy

Microtonics Associates, Inc.
Pittsburgh, PA 15213
* 112 - Heterostructure Infrared Detectors for Use at Wavelengths Longer than 14 Microns

Midwest Research Microscopy, Inc.
Milwaukee, WI 53218
053 - Erosion- and Oxidation-Resistant Protective Coating for Polyimide Sheeting

Monolithic Superconductors, Inc.
Lake Oswego, OR 97035-9998
166 - Novel Fabrication of Superconducting Antenna Structures for Space

MSNW, Inc.
San Marcos, CA 92069
051 - Synthesis of High-Purity Refractory Berylilides

Multisignal Technology Corporation
Los Alamitos, CA 90720
103 - A Neural Network Approach for Unsupervised Image Classification

Nastec, Inc./Transmission Research, Inc.
Cleveland, OH 44106
077 - Torque-Balanced Drives for Space Station Applications

Nektonics, Inc.
Waltham, MA 02154
* 227 - Chemical Vapor Deposition (CVD) Fluid Flow Simulation Modelling Tool

Netrologic, Inc.
San Diego, CA 92122
* 070 - A Feasibility Study of Discrete Adaptive Control and Adaptive Neural Networks for Robot Manipulators
102 - Adaptive Image Encoding and Classification Using Neural Networks
* 105 - A Natural Language Interface to a Geographical Information System

Newport Electro-Optics System, Inc.
Melbourne, FL 32935
* 106 - A Multichannel, Acoustic-Optic Bragg Cell RF Spectrum Analyzer System

Nielsen Engineering & Research, Inc.
Mountain View, CA 94043-2287
* 030 - Unstructured Triangular Mesh/Navier-Stokes Method for Aerodynamics of Aircraft with Ice Accretion

Northeast Semiconductor, Inc.
Ithaca, NY 14850
* 122 - Short Wavelength AlGaAs Diode Lasers

Northwest Research Associates, Inc.
Bellevue, WA 98009
198 - A New Method For Respiratory Monitoring During Space Flight

Odetics, Incorporated
Anaheim, CA 92805-2907
* 068 - Kinematics Development Tool for Manipulators with Redundant Degrees of Freedom
069 - Dual-Arm Collision Avoidance Algorithm
* 100 - KBS/DSP Image-Coding System

Olis Engineering
Sedalia, CO 80135
075 - Centerline Imaging System for End-Effector Tools

Optivision, Inc.
Palo Alto, CA 94303
* 107 - Fiber-Optic Interconnection Networks for Spacecraft

Optra, Incorporated
Beverly, MA 01915
* 121 - Auto-Aligned Fourier Transform Ultraviolet Spectrometer
* 137 - Fiber Optic Loop Antenna for the Measurement of Electric Currents in Space

Orbital Technologies Corporation
Middleton, WI 53719
* 225 - Microgravity Sonic Pump Levitator Furnace

P. C. Krause & Associates, Inc.
West Lafayette, IN 47906
* 174 - Control of Resonance in a 20 kHz Space Power System

Pacific Monolithics, Inc.
Sunnyvale, CA 94086
* 216 - Large Deviation Linear Phase Shifter

Panametrics, Inc.
Waltham, MA 02254
139 - Ultrasonic Transducers, Deployment and Signal Processing Means for Cryogens

PCP, Inc.
West Palm Beach, FL 33409
* 129 - Ion Mobility sensing of Extraterrestrial Volatiles from Gas Chromatography

PDA Engineering
Costa Mesa, CA 92626
* 180 - Generalized Failure Criteria for Laminated Carbon-Carbon

Penn Laboratories, Inc.
Cartersville, GA 30120
* 067 - Improvements to the Laser Float-Zone Process

Perceptics Corporation
Knoxville, TN 37933-0991
081 - Parallel Implementation of Algorithms for Robotic Sensory Fusion

Photonic Systems Inc.
Melbourne, FL 32901
140 - Wideband Acousto-Optic Spectrometer

Physical Research, Inc.
Torrance, CA 90505-6828
* 015 - Laser Velocimetry Processor for Hypersonic Flows

Physical Sciences Inc.
Alexandria, VA 22314
062 - The Stability of High-temperature Superconducting Materials in Low-Earth Orbits

Physical Sciences Inc.
Andover, MA 01810
* 007 - H_2/O_2 Three-Body Reaction Rates at High Temperatures (PC-121)
019 - Hypersonic Thermophysics Code
063 - Laser Technique in Superconducting Film Deposition

Program Development Corporation
White Plains, NY 10601
012 - Goodness-of-Grid Measures
184 - CAGD: Computer Aided Grid Design

Propulsion Research Associates
Westmont, IL 60559
002 - Efficient Computation of Viscous Internal Flows

PSI Technology
Andover, NA 01810
* 065 - Reduction of Oxygen and Other Products by Pyrolysis of Lunar Materials

Q-DOT, Inc.
Colorado Springs, CO 80907-3579
212 - Multiple-Access Communication Hybrid Simulation

QSource, Inc.
Avon, CT 06001
* 120 - Improved Pulsed-Discharge TE Laser

Rentech, Inc.
Huntsville, AL 35805
021 - Effects of Charge Separation in Hypersonic, Ionized Flows

Research Innovation Implementation, Inc.
Austin, TX 78758
038 - Sensors for Flight Research

Rose Engineering & Research, Inc.
Incline Village, NV 89450
144 - Innovative Shear Layer Control Methods for Large Scale Airborne Telescopes

SatCon Technology Corporation
Cambridge, MA 02142
109 - Magnetic Spindle Bearing for an Optical-Disk Buffer

Schmidt Instruments
Houston, TX 77005
* 147 - TOF-MS Leak Detectors

Schwartz Electro-Optics
Concord, MA 01742
* 117 - Diode-Pumped Laser Altimeter

Scientific Research Associates, Inc.
Glastonbury, CT 06033
010 - Automated Application of Navier-Stokes Solutions to Mechanical Design
037 - Fluorescence Spectroscopy and Thermometry for Hypersonic Flight Research
* 222 - Magnetic Float Zone Microgravity Crystal Growth/Application to Silicon Carbide

Scientific Technology, Inc.
Rockville, MD 20850
118 - A Compact Optical Rain Droplet Distrometer for Unattended Field Operation

SCS Telecom, Inc.
Port Washington, NY 11050
211 - Hybrid Projection Coding for the CCSDS Standard

SECA, Inc.
Huntsville, AL 35805
* 020 - Model Development for Exhaust Plume Effects on Launch Stand Design

Seer Systems, Inc.
Pittsburgh, PA 15237
* 085 - An Artificial Intelligence System for Process Monitoring, Situation Assessment, and Response Planning

Shason Microwave Corporation
Houston, TX 77058
* 213 - Integrated EVA Antenna Module for Space Station Multiple Access Communication

Sievers Research Inc.
Boulder, CO 80301
189 - Organic Removal Module for Ultra-Pure Water Recycle Systems

Software and Engineering Associates, Inc.
Carson City, NV 89701
* 182 - The Chemical Kinetics of LOX/Hydrocarbon Combustion

Software Productivity Solutions, Inc.
Melbourne, FL 32936-1697
* 092 - Reliable Specification for Ada Software
094 - Design Knowledge Capture

SoHaR Inc.
Beverly Hills, CA 90211
091 - Enhanced Condition Tables for Verification of Fault-Tolerant Software

SOL-3 Resources, Inc.
Reading, MA 01867
* 003 - Gas Turbine Combustor for Low Pattern Factor and Low NOx Emission

Southwest Sciences, Inc.
Santa Fe, NM 87501
* 027 - Non-Intrusive, Fast-Response Oxygen Monitoring System for High-Temperature Flows

Sparta, Inc.
Laguna Hills, CA 92653-1507
* 036 - Applications of Transputers in Aircraft Flight Research
042 - Expert Systems for Flight Control Systems Verification

Sparta, Inc.
Huntsville, AL 35805-6201
071 - Reaction Compensation System (RCS) for Microgravity Tele-Robots

Spectral Sciences, Inc.
Burlington, MA 01803-5169
* 145 - Trace Atmospheric Carbon Monoxide Sensor
* 210 - Conducting Organic Polymer Environmental Sensor (COPES)

Spectrum Management Group, Inc.
San Antonio, TX 78216
110 - Intelligent Information Management with Xylmaging

Spire Corporation
Bedford, MA 01730
124 - 2.1 Micrometer Lidar Detector
176 - Preparation of Superconducting Wire
208 - Thermal Tile Bond

SRS Technologies
Huntsville, AL 35806
209 - Air Mass Measurement Indicator for Portable Liquid Air Dewar

SSG, Inc.
Waltham, MA 02154
* 119 - Multi-Spectral High Resolution Remote Sensor
146 - Diagnostic Contamination Measurement for Space

Statistical Sciencies, Inc.
Seattle, WA 98145-1625
104 - Statistical Tools for Spatial Processes

Stirling Technology Company
Richland, WA 99352
* 155 - Thermal Control for Unmanned Space Applications

Sunpower, Inc.
Athens, OH 45701
167 - A Test Rig for Measuring Thermal Performance of Stirling Cycle Regenerators

System Specialists
Tucson, AZ 85713
148 - Detailed Visualization of Protein Crystal Growth

Systematix, Inc.
Nashville, TN 37211
173 - Implementation of Fault Tolerant Control Algorithms Using Neural Networks

Systolic Technology, Inc.
Mountain View, CA 94043
097 - Optical Drum for Space and Ground Applications

TAU Corporation
Los Gatos, CA 95032
* 161 - Worldwide Differential GPS for Space Shuttle Landing Operations

Technology Integration and Development Group
Billerica, MA 01821
047 - Continuous, On-Board, Non-Destructive Monitoring of Degradation in Stiffness and Strength of Fiber Composites

TeleRobotics International, Inc.
Knoxville, TN 37931
* 072 - Development of a Visual Language, Telerobotic Operator Interface for Rapid Implementation of Autonomous Tasks

The Eppley Laboratory, Inc.
Newport, RI 02840
* 115 - Improved Cavity Radiometer for Radiance Measurements

Top-Vu Technology
New Brighton, MN 55112
* 133 - GaAs Analog Preprocessing Electronics for Infrared Astronomical Applications

Tracer Technologies, Inc.
Somerville, MA 02145
055 - Titanium Carbide Used to Protect Carbon Composites

Transducer Research, Inc.
Naperville, IL 60540
202 - Energy-Modulated Toxic Vapor Detector

Triangle Research and Development Corporation
Research Triangle Park, NC 27709
194 - Vibration Isolation of Exercise Treadmill in Microgravity
197 - Spacesuit Glove-Liner with Enhanced Thermal Properties for Improved Comfort

Ultramet
Pacoima, CA 91331
052 - Hydrogen Collectors for Space Flight Applications

Umpqua Research Company
Myrtle Creek, OR 97457
* 186 - Regenerable Biocide Delivery Unit
* 190 - Catalytic Methods Using Molecular Oxygen for Treatment of PMMS and ECLSS Waste Streams
* 195 - Single Phase Space Laundry

Vexcel Corporation
Boulder, CO 80301
101 - Polarimetry-Based, SAR Shape from Shading for Terrain Reconstruction

Vigyan Research Associates, Inc.
Hampton, VA 23666
* 014 - Microcomputer Based Control of a Large Cryogenic Wind Tunnel

Visual Computing, Inc.
Mountain View, CA 94043
* 013 - Three-Dimensional Interactive Grid Generation Project

Wavemat, Inc.
Plymouth, MI 48170
066 - Sintering of Advanced Ceramic Materials with a Tunable Microwave Cavity

Wilson Greatbatch Ltd.
Clarence, NY 14031
* 219 - Low Temperature Electrolytes for Emergency Locator Transmitter

Appendix E

INDEX OF PRINCIPAL INVESTIGATORS

* *Project selected for Phase II*

* *Project selected for Phase II*

Appendix F

LIST OF PROJECTS BY NASA CENTER

AMES RESEARCH CENTER

012	88-1-02.01-4456
013*	88-1-02.01-5682
015*	88-1-02.05-0056
016	88-1-02.05-1050A
022*	88-1-02.08-0618
023*	88-1-02.08-9316B
024	88-1-02.09-7121
025*	88-1-02.09-9090
029*	88-1-03.01-0533
034	88-1-03.04-7300
035*	88-1-03.05-0533
036*	88-1-03.05-8161A
038	88-1-03.06-5287
039*	88-1-03.06-5649
041*	88-1-03.09-9915
042	88-1-03.10-8161
043	88-1-03.11-2526
093	88-1-06.04-6364
097	88-1-06.07-1467
098	88-1-06.07-3200
129*	88-1-08.10-0507
131	88-1-08.12-1856
133*	88-1-08.12-5925
144	88-1-08.19-5094
192*	88-1-12.04-6780
198	88-1-12.08-8141
199	88-1-12.08-9339

JET PROPULSION LABORATORY

057*	88-1-04.08-5224
061	88-1-04.10-1691
063	88-1-04.10-9030
068*	88-1-05.01-0300A
069	88-1-05.01-0300B
070*	88-1-05.01-1225
099*	88-1-06.08-4448
110	88-1-07.09-3221
112*	88-1-08.01-0888
113	88-1-08.01-1188
114*	88-1-08.01-7074
121*	88-1-08.05-7670
126	88-1-08.08-5649A
127	88-1-08.08-6100
128	88-1-08.09-1315
130*	88-1-08.11-5435A
132*	88-1-08.12-3800
138	88-1-08.14-7972
140	88-1-08.16-8181
143*	88-1-08.18-0700
171*	88-1-10.02-9450
178	88-1-10.06-8629
216*	88-1-14.04-8000
221*	88-1-14.09-2550
017	88-1-02.05-1050B

GODDARD SPACE FLIGHT CENTER

052	88-1-04.06-0236
076*	88-1-05.03-1100
079	88-1-05.03-7070
081	88-1-05.03-9200
089*	88-1-06.02-4242A
090	88-1-06.02-7910
101	88-1-07.02-0094
102	88-1-07.02-1225
106*	88-1-07.05-0300
107*	88-1-07.05-4429
111*	88-1-07.10-4651
115*	88-1-08.02-1020
117*	88-1-08.02-2299
118	88-1-08.02-6070
122*	88-1-08.06-3409
134*	88-1-08.13-2681
135*	88-1-08.13-3666
136	88-1-08.13-5411
137*	88-1-08.13-7670
141*	88-1-08.17-1520
142	88-1-08.17-7885
146	88-1-08.23-0204
155*	88-1-09.07-4000
156	88-1-09.07-4942B
157*	88-1-09.07-4942C
158*	88-1-09.07-7003
164*	88-1-09.12-8442
165	88-1-09.13-7070
166	88-1-09.14-2974
179	88-1-10.06-9450
214	88-1-14.02-0755
215*	88-1-14.02-2250
219*	88-1-14.07-6901

KENNEDY SPACE CENTER

200*	88-1-12.10-4569
201*	88-1-12.10-7070
202	88-1-13.01-1336A
203*	88-1-13.01-9450A
204	88-1-13.02-2664
205*	88-1-13.02-7003B
206	88-1-13.03-0070A
207*	88-1-13.03-7800
208	88-1-13.04-6000
209	88-1-13.06-7000

JOHNSON SPACE CENTER

053	88-1-04.07-2260
055	88-1-04.07-6410
056*	88-1-04.07-9399
064	88.1-04.11-4415
065*	88-1-04.11-9030
082*	88-1-05.04-5900
083*	88-1-05.04-8622
085*	88-1-05.05-4502
086	88-1-05.05-4917
088	88-1-05.05-7300
095*	88-1-06.06-1625B
096*	88-1-06.06-4570
150*	88-1-09.03-2567A
151	88-1-09.03-8933
152	88-1-09.05-3200
159	88-1-09.09-4995
160	88-1-09.09-8050
161*	88-1-09.09-9191
186*	88-1-12.01-52201A
187*	88-1-12.01-8610
188	88-1-12.01-9396
191*	88-1-12.03-4100
193	88-1-12.05-5801
194	88-1-12.05-8148
195*	88-1-12.06-5201B
196	88-1-12.06-9200
197	88-1-12.07-8148
210*	88-1-13.08-4770
211	88-1-14.01-0760B
212	88-1-14.01-1112
213*	88-1-14.01-4341

** Project selected for Phase II*

LANGLEY RESEARCH CENTER

014*	88-1-02.02-0794
018*	88-1-02.05-8848
019	88-1-02.05-9030A
026	88-1-02.11-0161
027*	88-1-02.11-1322
028	88-1-02.12-3077
031*	88-1-03.02-9282
032*	88-1-03.03-0371
033	88-1-03.03-9316A
037	88-1-03.06-0333
040	88-1-03.07-1500
044	88-1-03.11-3474
048*	88-1-04.03-3200A
049	88-1-04.03-5224
050	88-1-04.03-7356R
051	88-1-04.04-7648
058*	88-1-04.09-6425A
059*	88-1-04.09-7780
072*	88-1-05.01-5600
074	88-1-05.01-8500
080	88-1-05.03-8822
091	88-1-06.03-2595
092*	88-1-06.03-3370
100*	88-1-07.01-5000
108	88-1-07.06-0040
109	88-1-07.06-0540
123*	88-1-08.07-0755
124	88-1-08.07-6000
125	88-1-08.07-7067D
149*	88-1-09.01-1500
172*	88-1-10.04-3666
227*	88-1-15.03-5777

LEWIS RESEARCH CENTER

001*	88-1-01.01-1515
002	88-1-01.01-1708A
003*	88-1-01.02-0731
004	88-1-01.03-0690A
005*	88-1-01.03-5709A
006*	88-1-01.03-7070
007*	88-1-01.04-9030
008	88-1-01.05-0999
009*	88-1-01.06-9282
030*	88-1-03.01-9457
045	88-1-04.01-1049
046	88-1-04.01-2681
047	88-1-04.02-3779
054	88-1-04.07-3812
060	88-1-04.10-0161
062	88-1-04.10-6410A
066	88-1-04.12-2010
067*	88-1-04.12-8476
077	88-1-05.03-1391
139	88-1-08.15-2719
147*	88-1-08.24-9040
167	88-1-10.01-2221
168	88-1-10.01-3200A
169*	88-1-10.01-6696
170	88-1-10.01-7270A
177	88-1-10.06-7241
217*	88-1-14.05-4114
218*	88-1-14.05-9388
220	88-1-14.08-7111B
223*	88-1-15.01-5544
224	88-1-15.01-5800
226*	88-1-15.02-0200
228	88-1-15.04-8200

MARSHALL SPACE FLIGHT CENTER

010	88-1-02.01-0333A
011*	88-1-02.01-0618
020*	88-1-02.06-2008A
021	88-1-02.07-8581
071	88-1-05.01-5200
073	88-1-05.01-8024
075	88-1-05.03-0718
078	88-1-05.03-5649
084*	88-1-05.05-2200
087*	88-1-05.05-5500
094	88-1-06.05-3370
116*	88-1-08.02-1982
120*	88-1-08.04-2260
145*	88-1-08.22-4770
148	88-1-08.25-7513
153*	88-1-09.06-3200
154	88-1-09.06-6576A
162*	88-1-09.10-8100
163	88-1-09.11-8600
173	88-1-10.05-1319
174*	88-1-10.05-9685
175*	88-1-10.06-2681
176	88-1-10.06-6000
180*	88-1-11.01-8900B
181	88-1-11.03-0688
182*	88-1-11.03-1966
183	88-1-11.03-8122
184	88-1-11.04-4456
185*	88-1-11.04-6576A
189	88-1-12.02-2009
190*	88-1-12.02-5201
222*	88-1-15.01-0333
225*	88-1-15.01-6684

STENNIS SPACE CENTER

103	88-1-07.02-3503
104	88-1-07.03-8707
105*	88-1-07.04-1225
119*	88-1-08.03-0204

** Project selected for Phase II*

Appendix G

INDEX OF PROJECTS BY CONTRACT NUMBER

1: LANGLEY RESEARCH CENTER

NAS1-18802	018*	88-1-02.05-8848
NAS1-18803	125	88-1-08.07-7067D
NAS1-18804	037	88-1-03.06-0333
NAS1-18805	033	88-1-03.03-9316A
NAS1-18806	044	88-1-03.11-3474
NAS1-18807	019	88-1-02.05-9030A
NAS1-18808	080	88-1-05.03-8822
NAS1-18809	108	88-1-07.06-0040
NAS1-18810	014*	88-1-02.02-0794
NAS1-18811	091	88-1-06.03-2595
NAS1-18812	032*	88-1-03.03-0371
NAS1-18813	172*	88-1-10.04-3666
NAS1-18814	074	88-1-05.01-8500
NAS1-18815	026	88-1-02.11-0161
NAS1-18816	100*	88-1-07.01-5000
NAS1-18817	048*	88-1-04.03-3200A
NAS1-18818	149*	88-1-09.01-1500
NAS1-18819	031*	88-1-03.02-9282
NAS1-18820	028	88-1-02.12-3077
NAS1-18821	051	88-1-04.04-7648
NAS1-18822	109	88-1-07.06-0540
NAS1-18823	072*	88-1-05.01-5600
NAS1-18824	058*	88-1-04.09-6425A
NAS1-18825	050	88-1-04.03-7356R
NAS1-18826	092*	88-1-06.03-3370
NAS1-18827	123*	88-1-08.07-0755
NAS1-18828	124	88-1-08.07-6000
NAS1-18829	027*	88-1-02.11-1322
NAS1-18830	059*	88-1-04.09-7780
NAS1-18831	227*	88-1-15.03-5777
NAS1-18832	049	88-1-04.03-5224

2: AMES RESEARCH CENTER

NAS2-12886	038	88-1-03.06-5287
NAS2-12887	036*	88-1-03.05-8161A
NAS2-12888	042	88-1-03.10-8161
NAS2-12889	039*	88-1-03.06-5649
NAS2-12890	035*	88-1-03.05-0533
NAS2-12959	012	88-1-02.01-4456
NAS2-12960	013*	88-1-02.01-5682
NAS2-12962	025*	88-1-02.09-9090
NAS2-12963	093	88-1-06.04-6364
NAS2-12964	097	88-1-06.07-1467
NAS2-12965	041*	88-1-03.09-9915
NAS2-12967	034	88-1-03.04-7300
NAS2-12968	098	88-1-06.07-3200
NAS2-12969	016	88-1-02.05-1050A
NAS2-12970	015*	88-1-02.05-0056
NAS2-12972	043	88-1-03.11-2526
NAS2-12973	199	88-1-12.08-9339
NAS2-12987	133*	88-1-08.12-5925
NAS2-12988	024	88-1-02.09-7121
NAS2-12989	023*	88-1-02.08-9316B
NAS2-12990	131	88-1-08.12-1856
NAS2-12991	192*	88-1-12.04-6780
NAS2-12994	198	88-1-12.08-8141
NAS2-12997	129*	88-1-08.10-0507
NAS2-13000	022*	88-1-02.08-0618
NAS2-13034	144	88-1-08.19-5094
NAS2-18801	040	88-1-03.07-1500

** Project selected for Phase II*

3: LEWIS RESEARCH CENTER

NAS3-25371	139	88-1-08.15-2719
NAS3-25372	147*	88-1-08.24-9040
NAS3-25558	168	88-1-10.01-3200A
NAS3-25562	062	88-1-04.10-6410A
NAS3-25563	003*	88-1-01.02-0731
NAS3-25564	054	88-1-04.07-3812
NAS3-25565	217*	88-1-14.05-4114
NAS3-25566	007*	88-1-01.04-9030
NAS3-25567	045	88-1-04.01-1049
NAS3-25568	060	88-1-04.10-0161
NAS3-25569	046	88-1-04.01-2681
NAS3-25573	002	88-1-01.01-1708A
NAS3-25574	009*	88-1-01.06-9282
NAS3-25575	047	88-1-04.02-3779
NAS3-25576	077	88-1-05.03-1391
NAS3-25601	030*	88-1-03.01-9457
NAS3-25604	001*	88-1-01.01-1515
NAS3-25604	228	88-1-15.04-8200
NAS3-25605	067*	88-1-04.12-8476
NAS3-25606	220	88-1-14.08-7111B
NAS3-25607	005*	88-1-01.03-5709A
NAS3-25608	066	88-1-04.12-2010
NAS3-25610	169*	88-1-10.01-6696
NAS3-25612	226*	88-1-15.02-0200
NAS3-25613	224	88-1-15.01-5800
NAS3-25614	177	88-1-10.06-7241
NAS3-25616	008	88-1-01.05-0999
NAS3-25617	006*	88-1-01.03-7070
NAS3-25617	218*	88-1-14.05-9388
NAS3-25618	029*	88-1-03.01-0533
NAS3-25619	004	88-1-01.03-0690A
NAS3-25620	167	88-1-10.01-2221
NAS3-25621	170	88-1-10.01-7270A
NAS3-25627	223*	88-1-15.01-5544

5: GODDARD SPACE FLIGHT CENTER

NAS5-30455	079	88-1-05.03-7070
NAS5-30456	136	88-1-08.13-5411
NAS5-30457	141*	88-1-08.17-1520
NAS5-30458	155*	88-1-09.07-4000
NAS5-30459	081	88-1-05.03-9200
NAS5-30481	102	88-1-07.02-1225
NAS5-30482	117*	88-1-08.02-2299
NAS5-30483	111*	88-1-07.10-4651
NAS5-30484	118	88-1-08.02-6070
NAS5-30485	052	88-1-04.06-0236
NAS5-30486	106*	88-1-07.05-0300
NAS5-30487	214	88-1-14.02-0755
NAS5-30488	090	88-1-06.02-7910
NAS5-30489	146	88-1-08.23-0204
NAS5-30490	164*	88-1-09.12-8442
NAS5-30491	165	88-1-09.13-7070
NAS5-30492	219*	88-1-14.07-6901
NAS5-30493	122*	88-1-08.06-3409
NAS5-30494	179	88-1-10.06-9450
NAS5-30495	157*	88-1-09.07-4942C
NAS5-30496	135*	88-1-08.13-3666
NAS5-30497	076*	88-1-05.03-1100
NAS5-30498	142	88-1-08.17-7885
NAS5-30499	137*	88-1-08.13-7670
NAS5-30501	107*	88-1-07.05-4429
NAS5-30502	089*	88-1-06.02-4242A
NAS5-30504	166	88-1-09.14-2974
NAS5-30519	158*	88-1-09.07-7003
NAS5-30595	156	88-1-09.07-4942B
NAS5-30596	101	88-1-07.02-0094
NAS5-30597	115*	88-1-08.02-1020
NAS5-30598	134*	88-1-08.13-2681
NAS5-30599	215*	88-1-14.02-2250

** Project selected for Phase II*

7: JET PROPULSION LABORATORY

NAS7-1038	069	88-1-05.01-0300B
NAS7-1039	114*	88-1-08.01-7074
NAS7-1040	143*	88-1-08.18-0700
NAS7-1041	132*	88-1-08.12-3800
NAS7-1042	171*	88-1-10.02-9450
NAS7-1043	113	88-1-08.01-1188
NAS7-1044	128	88-1-08.09-1315
NAS7-1045	221*	88-1-14.09-2550
NAS7-1046	099*	88-1-06.08-4448
NAS7-1047	138	88-1-08.14-7972
NAS7-1048	140	88-1-08.16-8181
NAS7-1049	110	88-1-07.09-3221
NAS7-1050	061	88-1-04.10-1691
NAS7-1051	112*	88-1-08.01-0888
NAS7-1052	130*	88-1-08.11-5435A
NAS7-1053	057*	88-1-04.08-5224
NAS7-1054	126	88-1-08.08-5649A
NAS7-1055	068*	88-1-05.01-0300A
NAS7-1056	216*	88-1-14.04-8000
NAS7-1057	063	88-1-04.10-9030
NAS7-1058	070*	88-1-05.01-1225
NAS7-1059	178	88-1-10.06-8629
NAS7-1060	121*	88-1-08.05-7670
NAS7-1061	127	88-1-08.08-6100

8: MARSHALL SPACE FLIGHT CENTER

NAS8-38020	010	88-1-02.01-0333A
NAS8-38021	071	88-1-05.01-5200
NAS8-38022	183	88-1-11.03-8122
NAS8-38023	175*	88-1-10.06-2681
NAS8-38024	084*	88-1-05.05-2200
NAS8-38025	180*	88-1-11.01-8900B
NAS8-38026	148	88-1-08.25-7513
NAS8-38027	094	88-1-06.05-3370
NAS8-38028	020*	88-1-02.06-2008A
NAS8-38029	075	88-1-05.03-0718
NAS8-38030	222*	88-1-15.01-0333
NAS8-38031	162*	88-1-09.10-8100
NAS8-38032	021	88-1-02.07-8581
NAS8-38033	120*	88-1-08.04-2260
NAS8-38034	154	88-1-09.06-6576A
NAS8-38035	174*	88-1-10.05-9685
NAS8-38036	087*	88-1-05.05-5500
NAS8-38037	184	88-1-11.04-4456
NAS8-38038	190*	88-1-12.02-5201
NAS8-38039	176	88-1-10.06-6000
NAS8-38040	116*	88-1-08.02-1982
NAS8-38042	185*	88-1-11.04-6576A
NAS8-38042	225*	88-1-15.01-6684
NAS8-38043	181	88-1-11.03-0688
NAS8-38044	078	88-1-05.03-5649
NAS8-38045	189	88-1-12.02-2009
NAS8-38046	011*	88-1-02.01-0618
NAS8-38047	073	88-1-05.01-8024
NAS8-38048	145*	88-1-08.22-4770
NAS8-38049	173	88-1-10.05-1319
NAS8-38050	153*	88-1-09.06-3200
NAS8-38051	163	88-1-09.11-8600
NAS8-38052	182*	88-1-11.03-1966

9: JOHNSON SPACE CENTER

NAS9-18083	088	88-1-05.05-7300
NAS9-18084	159	88-1-09.09-4995
NAS9-18085	191*	88-1-12.03-4100
NAS9-18086	187*	88-1-12.01-8610
NAS9-18087	056*	88-1-04.07-9399
NAS9-18088	017	88-1-02.05-1050B
NAS9-18089	196	88-1-12.06-9200
NAS9-18090	193	88-1-12.05-5801
NAS9-18090	053	88-1-04.07-2260
NAS9-18091	151	88-1-09.03-8933
NAS9-18092	064	88.1-04.11-4415
NAS9-18093	082*	88-1-05.04-5900
NAS9-18094	150*	88-1-09.03-2567A
NAS9-18095	188	88-1-12.01-9396
NAS9-18096	160	88-1-09.09-8050
NAS9-18097	083*	88-1-05.04-8622
NAS9-18098	152	88-1-09.05-3200
NAS9-18099	095*	88-1-06.06-1625B
NAS9-18100	096*	88-1-06.06-4570
NAS9-18102	065*	88-1-04.11-9030
NAS9-18103	212	88-1-14.01-1112
NAS9-18104	085*	88-1-05.05-4502
NAS9-18105	211	88-1-14.01-0760B
NAS9-18106	213*	88-1-14.01-4341
NAS9-18107	210*	88-1-13.08-4770
NAS9-18108	161*	88-1-09.09-9191
NAS9-18109	055	88-1-04.07-6410
NAS9-18110	197	88-1-12.07-8148
NAS9-18111	194	88-1-12.05-8148
NAS9-18112	195*	88-1-12.06-5201B
NAS9-18113	186*	88-1-12.01-52201A
NAS9-18114	086	88-1-05.05-4917

10: KENNEDY SPACE CENTER

NAS10-11556	204	88-1-13.02-2664
NAS10-11557	203*	88-1-13.01-9450A
NAS10-11558	208	88-1-13.04-6000
NAS10-11559	201*	88-1-12.10-7070
NAS10-11560	200*	88-1-12.10-4569
NAS10-11561	202	88-1-13.01-1336A
NAS10-11562	207*	88-1-13.03-7800
NAS10-11563	209	88-1-13.06-7000
NAS10-11564	206	88-1-13.03-0070A
NAS10-11565	205*	88-1-13.02-7003B

13: STENNIS SPACE CENTER

NAS13-381	103	88-1-07.02-3503
NAS13-383	104	88-1-07.03-8707
NAS13-384	105*	88-1-07.04-1225
NAS13-385	119*	88-1-08.03-0204

** Project selected for Phase II*

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Patricia Sullivan
NASA
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Washington, DC 20546

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