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National Aeronautics and  
Space Administration

Resident

Research

Associateships

Postdoctoral and  
Senior Research Awards

1984

tenable at the  
GEORGE C. MARSHALL  
SPACE FLIGHT CENTER  
Huntsville, Alabama

administered by the  
NATIONAL RESEARCH COUNCIL  
National Academy of Sciences  
National Academy of Engineering  
Institute of Medicine

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# **Resident Research Associateships**

## **Postdoctoral and Senior Research Awards**

1984

OPPORTUNITIES FOR RESEARCH  
at the  
GEORGE C. MARSHALL SPACE FLIGHT CENTER  
Huntsville, Alabama 35812

in association with the  
NATIONAL RESEARCH COUNCIL  
National Academy of Sciences  
National Academy of Engineering  
Institute of Medicine  
2101 Constitution Avenue  
Washington, D.C. 20418

## Foreword

The George C. Marshall Space Flight Center of NASA is located near Huntsville, in the heart of north Alabama's productive Tennessee Valley. The Marshall Center, directed by Dr. William R. Lucas, has approximately 3,500 employees. Approximately 2,200 employees hold professional degrees and over 100 hold Ph.D.'s in the physical sciences and engineering. The Resident Research Associateship program at the Marshall Center is managed by Dr. Fred A. Speer, Associate Director for Science.

The laboratories within the Science and Engineering element of the Center provide research opportunities for Resident Research Associates. The missions of the Center are the design and development of space transportation systems, tailored to manned and unmanned payload requirements; design and development of scientific payloads, payload carriers and other systems required for ongoing and future space exploration; systems engineering and overall systems integration of vehicles and payloads; planning and implementation of a space-materials processing program; research related to space exploration in the science and engineering disciplines; and technical program management of programs involving space vehicles, payloads, and systems. The Marshall Center has more than 150 buildings with extensive laboratory facilities located on its 1,800 acres.

The University of Alabama in Huntsville has an undergraduate school and a graduate school with an extensive curriculum in the physical sciences and engineering. Alabama A&M University and Oakwood College are also located in Huntsville. An excellent library exists at the Redstone Scientific Information Center, sponsored jointly by the Army and NASA. It has an outstanding collection of technical literature.

Huntsville is also the home of the Redstone Arsenal, where the U.S. Army conducts military rocket research and development. Huntsville is known as the "Space Capital of the U.S." It is one of the oldest communities in the State of Alabama, dating from 1805. The population in 1980 was approximately 140,000. A modern jet airport serves the air-transportation needs of this community. Recreation opportunities abound nearby on the numerous lakes of the Tennessee River and in the heavily wooded mountains. The major cities of Nashville, Birmingham, and Atlanta are within a few hours drive of Huntsville.

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# Contents

INTRODUCTION	1
OPPORTUNITIES FOR RESEARCH	
Materials and Processes Laboratory	9
Space Science Laboratory	13
Systems Dynamics Laboratory	17
INDEX OF LABORATORY DIRECTORS AND RESEARCH ADVISERS	21

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# Introduction

## General Information

The National Research Council (NRC) conducts the Resident Research Associateship Programs in cooperation with a number of sponsoring Federal laboratories and research organizations approved by the NRC for participation. In the programs, a national competition is conducted by the NRC to recommend and make awards to outstanding scientists and engineers at the recent postdoctoral and experienced senior levels for tenure as guest investigators at the participating laboratories. These programs have been conducted with a number of Federal agencies since 1954.

The objectives of the program are

- to provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are compatible with the research interests of the sponsoring laboratories and
- to contribute thereby to the overall research effort of the Federal laboratories.

These programs are intended to be analogous to fellowships, associateships, and similar temporary programs at the doctoral level in universities and other organizations. They are neither intended to be, nor to compete with, permanent professional career positions.

- An NRC Resident Research Associate is a guest investigator, not an employee of the National Research Council or of the laboratory, and there is no obligation to either organization during or after completion of tenure.

For recent doctoral graduates, the program provides an opportunity for concentrated research in association with selected members of the permanent professional laboratory staff, often as a climax to formal career preparation. For established scientists and engineers, the program affords an opportunity for research without the interruptions and distracting assignments of permanent career positions. The participating laboratories and centers receive a stimulus to their research programs by the presence of bright, highly motivated recent doctoral graduates and senior investigators with established records of research productivity. New ideas, techniques, and approaches to problems contribute to the overall research climate of the laboratories. Indirectly, the program also makes available to the broader scientific and engineering communities

the excellent and often unique research facilities that exist in the government's laboratories

Applications for awards will be received by the Associateship Programs office of the NRC and will be evaluated on a competitive basis by special NRC panels of scientists and engineers. For the 1984 program year, it is anticipated that approximately 1,000 applications will be received for the nearly 250 new awards to be made in the NRC Research Associateship Programs.

Described in this booklet are areas of research in which Research Associateships may be awarded at the George C. Marshall Space Flight Center (MSFC). Each applicant is responsible for formulating a specific research plan on a problem that is related to the current research interests of the laboratory in which the applicant wishes to do research.

Applicants whose research interests appear to be related to one or more of the opportunities described in this booklet are advised to communicate directly with the research advisers who are designated for those areas of research. Research advisers can provide more specific information on current research programs and available technical facilities. Further inquiries concerning research opportunities and advisers may be directed to the NRC-NASA Laboratory Program Representative:

Dr. Fred A. Speer  
Associate Director for Science  
D530  
Marshall Space Flight Center, Alabama 35812  
Telephone: (205) 453-3033

Each applicant's proposed plan of research must be approved by one of the research advisers listed herein and endorsed by the program committee of the MSFC to be eligible for an award. The endorsement affirms that the proposed research problem is compatible with the laboratory's interest and that adequate programmatic support will be available if an award is offered. A written response regarding each applicant's proposed research problem must be received from the laboratory by the Associateship Programs office before an applicant will be reviewed by the NRC evaluation panels. The Center's action on the research proposal, together with a copy of the adviser's comments, will be provided directly to the applicant by the NRC Program Representative at the MSFC. It must also be determined that the applicant is acceptable for resident status at a NASA Center.

- All applicants should note that endorsement by a research adviser and/or laboratory, while an essential component of the application process, must not be assumed to imply or guarantee an award by the NRC. Applicants are formally recommended for awards only after open, national competition, in which special NRC-appointed panels rank candidates on the basis of quality alone. Final ranking in order of quality and the recommendation of applicants for awards are the exclusive prerogatives of these panels, and notification only by the NRC of an applicant's status in the competition is authoritative.

## Eligibility of Applicants

### Citizenship

Research opportunities in basic science and applied science and technology described in this booklet are open to all citizens of the United States.

- Non-U.S. citizens may submit research proposals in basic science areas only and must have full command of the English language. Non-U.S. nationals who become Associates must have valid visas throughout tenure. Only Exchange Visitor and Immigrant Visas are acceptable to the NRC. If an awardee chooses to apply for an Exchange Visitor Visa, the sponsorship must be under the NRC. If one chooses to apply for a U.S. Immigrant Visa, the NRC will not be involved in the matter.

### Education and Experience

Awardees must hold the Ph.D., Sc.D., or other earned research doctoral degree recognized in U.S. academic circles as equivalent to the Ph.D. or must present acceptable evidence of having completed all the formal academic requirements for one of these degrees before tenure may be initiated. Applicants must have demonstrated superior ability for creative research. An applicant's training and research experience may be in any appropriate discipline or combination of disciplines required for the proposed research.

### Prior Affiliation with the Laboratory

A primary objective of the Associateship Programs is to provide a mechanism for new ideas and new sources of stimulation to be brought to the sponsoring laboratory. Thus, persons with substantial recent prior affiliation with a specific laboratory may not be eligible to apply for an Associateship at that laboratory.

Substantial recent prior affiliation includes direct employment relationships either with the laboratory or with a contractor whose work is performed at the laboratory. A long-term consulting relationship with the laboratory usually makes the applicant ineligible. Research contracts with universities that provide support for graduate students and faculty performing research on the campus are not ordinarily considered disqualifying.

### Reapplication

Persons who have previously held an NRC Research Associateship may apply for another award only if a period of at least two years will have



elapsed between termination of the first award and the proposed tenure of a second award. Persons who have previously applied for an NRC Associateship, but who were not recommended for an award by the NRC panels, may reapply after one year. Candidates who were recommended for an award by the NRC panels, but who were not offered an award because of funding or other limitations, may reapply at any time without a mandatory waiting period.

### Consideration

Qualified applicants will receive consideration without regard to race, creed, color, age, sex, or national origin.

### Conditions of the Award

**Regular Research Associateships** will be awarded to persons who have held the doctorate less than five years at the time of application and will be made initially for one year.

**Senior Research Associateships** are awarded only to investigators who have held the doctorate five years or more at the time of application. Senior applicants should have research experience that has resulted in significant contributions and recognition as established investigators in their specialized fields. Awards to senior Associates will generally be for one year; however, awards for shorter periods will be considered.

Under certain conditions, extensions will be granted to allow Associates to bring their research programs to a reasonable stage of completion. An extension must not be assumed.

- No commitment on the part of an Associate, the sponsoring laboratory, or the NRC with regard to later employment is implied or should be inferred by the offer or acceptance of an award.

These Research Associateships are tenable only at the approved, participating laboratories listed in this booklet. No period of the Associateship tenure may be spent in residence at another laboratory or institution. Associates will have the status of visiting scientists or engineers in the laboratory but will be subject to the general working conditions at the laboratory. The George C. Marshall Space Flight Center, which provides the funds to support this program, will furnish all necessary support services, facilities, and equipment for the approved research program of each Associate.

- Although applications for NRC-NASA Research Associateships will be accepted throughout the year, they will be evaluated in competition only during certain periods. Three competitive reviews will be held in 1984. Completed applications that are postmarked not later than January 15, April

15, and August 15, and received by the NRC not later than January 25, April 25, and August 25, will be reviewed for announcement of awards in March, July, and November, respectively. The NRC must be advised by the MSFC that the proposed research has been approved; otherwise, the NRC will assume that the proposed research is not of sufficient current interest to NASA or that support facilities cannot be made available.

Associateship awards will be made by the NRC. The date on which tenure of an Associateship award may begin is negotiated on an individual basis. Tenure should normally begin within six months of the award; however, the starting date may be delayed by mutual agreement of the MSFC, the Associate, and the NRC. Sufficient time must be allowed between the offer of an award and the beginning of tenure to enable the NRC and the MSFC to complete all necessary administrative procedures. The starting date cannot be later than 12 months from the date of the original award. If this condition cannot be met, a new application, including a newly approved plan of research, must be submitted to the NRC and will be judged without prejudice in the next competition.

- While every effort has been made by the participating Center or laboratory to provide Research Opportunities of ample scope and relevance, the appearance of any Research Opportunity in this booklet does not guarantee that it will be available at the time Associateship awards are offered. Changes and/or deletions may occur following the publication of this booklet, and all opportunities are subject to final review and approval by the laboratory and the NRC prior to the awarding of tenure.

## Stipend

A Research Associate will receive a stipend from the NRC while carrying out the research proposed as part of the application procedure. The current stipend for a regular Research Associate is at the annual rate of \$24,500. The base is subject to adjustments from time to time in accordance with general national guidelines pertaining to scientists and engineers. An appropriately higher stipend will be offered to senior Associates.

Following current salary practices in certain professional fields that are experiencing a short supply of new doctoral graduates, a stipend supplement may be allotted by the NRC to awardees in those disciplines. For the 1984 program year, stipend supplements of up to \$5,000 may be added to the basic stipend for regular awardees holding recognized doctoral degrees in engineering, computer science, and clinical space-biomedical science.

- Applicants are cautioned against entering into any agreement or understanding with individual Research Advisers or other laboratory personnel concerning additional funding or other remuneration for work as an Associate. Stipends for Research Associates are limited to the amounts and by the

conditions set forth above, and any other arrangement, formal or informal, between an applicant and laboratory personnel for additional monies or other considerations is strictly prohibited by the NRC.

### **Commitment**

Associates must devote their full-time effort to the approved research program and must be in residence at the sponsoring laboratory during the entire period of the Associateship. No additional monetary aid or other remuneration may be accepted from another appointment, fellowship, or similar grant, except for sabbatical leave, during the period of the Associateship.

### **Taxes and Insurance**

All Associates are, in effect, self-employed. All arrangements for payment of income taxes are the responsibility of the individual Associate. An appropriate amount, estimated to approximate the tax liability of foreign nationals, will be withheld by the NRC from stipends of non-U.S. Associates on Exchange Visitor Visas. Details will be provided at the time of the award. Job-related injury or death will be covered by insurance (workmen's-compensation type). A group health insurance program is required for Associates and optional for dependents.

### **Relocation and Travel**

A suitable relocation reimbursement will be determined for each awardee. Details will be provided at the time of the award. Funds will also be made available for limited professional travel during tenure, provided such travel is recommended in advance by an Associate's research adviser at the MSFC and approved by the NRC.

### **Publication**

Since an Associate's later scientific and technical career will be judged by others, publication in the accepted open technical literature is highly encouraged. Publications should include a statement indicating that the research was conducted while the author held an NRC Research Associateship.

### **Summary of the Application Procedure**

For further details on the application procedure, refer to the Instructions that accompany the application packet.

- The Associateship Programs office of the NRC will receive all applications and supporting documents and conduct the competitive evaluation of applications.

- Detailed information on application procedures, all necessary forms, and a list of the supporting documents required are available on request from the

Associateship Programs (JH 608)  
National Research Council  
2101 Constitution Avenue, N.W.  
Washington, D.C. 20418

- Application materials from previous competitions must not be used.
- Submit the following to the Associateship Programs office:

Signed Application form  
Office Card  
Research Proposal (one copy with original signature on each page)  
Approval of Research Form (one set)  
Previous and Current Research form

- The above application materials must be postmarked no later than January 15, 1984, April 15, 1984, and August 15, 1984, and must be received in the Associateship Programs office no later than January 25, April 25, and August 25, respectively.

- Have the following sent directly to the Associateship Programs office:

Official transcripts of all graduate and undergraduate credits (not required for senior applicants)

Four Reference Reports from the respondents listed on the Application. Only official Reference Report forms may be used by regular applicants. Letters of reference will be accepted for senior applicants. Senior applicants should endeavor to include some references from individuals who are not co-employees.

- The above supporting documents must be received by the NRC by February 15, June 1, and October 1, respectively.

- The NRC will forward the Research Proposal to the NASA Center Program Representative, who will direct it to the appropriate research adviser indicated on the form. The research adviser will review the Research Proposal and forward it to the Center's program committee for endorsement.

- No applicant will be eligible for an award without the research adviser's approval of the Research Proposal and its endorsement by the program committee at the laboratory.

- Completed applications that have been postmarked January 15, April 15, and August 15 and endorsed by the NASA Center will be reviewed by the NRC panels in February, June, and October, respectively.

- The Associateship Programs office will notify applicants of the disposition of their applications in March, July, and November, respectively.
- Awards will be offered by the NRC to the extent of available spaces and funding, and acceptances or declinations must be made to the NRC.

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The National Research Council administers NRC-NASA Research Associateships at the following NASA Centers: Ames Research Center, Moffett Field, California; Dryden Flight Research Facility, Edwards Air Force Base, California; Goddard Space Flight Center, Greenbelt, Maryland; Jet Propulsion Laboratory, Pasadena, California; Johnson Space Center, Houston, Texas; Langley Research Center, Hampton, Virginia; Lewis Research Center, Cleveland, Ohio; and Marshall Space Flight Center, Huntsville, Alabama.

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## Opportunities For Research

The Marshall Space Flight Center research program offers opportunities for original work in many areas of the physical sciences, in mathematics, and in engineering. The advanced research and development activities are conducted primarily in the laboratories of the Science and Engineering Directorates of the Center. Applicants interested in a particular laboratory should write to the Director of the Laboratory. The Director will arrange for appropriate technical personnel, normally the Research Advisers, to communicate with the applicant. Names of potential Research Advisers are shown for each research opportunity.

### **Materials and Processes Laboratory** **R.J. Schwinghamer, Director**

The Materials and Processes Laboratory conducts research in support of space-vehicle and payloads development. Major technology and research efforts are under way in physics and chemistry of materials, both metallic and nonmetallic, and in critical environments at cryogenic to high-temperature levels. In addition, comprehensive research and development activities are pursued in qualification and testing of materials. The laboratory also develops flight experiments and processing equipment in order to study the effects of weightlessness on materials processing in space.

The laboratory is equipped with modern facilities to support in-depth experimental research in areas such as heat transfer, two-phase flow, cryogenics, passive and active thermal control, and space radiation effects on materials and has extensive facilities for chemistry and physics, including the latest metallurgical and nondestructive testing capabilities. For terrestrial testing of space processes, drop-tower testing and a full-scale concept-verification test module for the SPACELAB to be carried by the SPACE SHUTTLE are available. The laboratory is instrumental in a space processing experiment program using sounding rockets as a test bed for the development of SPACE SHUTTLE payloads in the area of materials-manufacturing processes.

#### **Fluid Lubricants**

A.F. Whitaker

44.70.62.01

The environments of outer space have proven exceptionally hazardous to the operation of mechanical components because of the inability of normal fluid

lubricants to operate in hard vacuum and at both high and low temperatures. Therefore, a major research program is under way to evaluate various synthetic and highly refined mineral oils in a variety of simulated space environments. This program covers both theoretical studies in hydrodynamic and elastohydrodynamic film formation and statistical studies of thousands of bearing tests being conducted in special environmental chambers from one to five years. The results to date have led to special emphasis on a class of synthetic lubricants designated as perfluoroalkypoly-ethers. These fluids, as a class, are fully fluorinated and are therefore exceptionally stable. A recent improvement in this synthetic has provided a vacuum-stable lubricant capable of operation from less than  $-70^{\circ}\text{C}$  to over  $250^{\circ}\text{C}$ . The effect of Hertz-range pressures on fluid viscosity is currently being investigated for these and other space-compatible lubricant systems. The work being carried out in this area includes complete characterization of the test fluids using viscometers and extreme-pressure test equipment. Although considerable progress has been made in the development of fluid lubricants for use in space, an almost unlimited amount of research still waits to meet the ever-increasing demands of future space programs.

#### **Metallic Materials Research**

B.N. Bhat

44.70.62.02

The laboratory has a wide array of metallurgical research and engineering projects under way for advancing material properties to fit SPACE SHUTTLE requirements. These include development of improved alloys and processes to achieve reliable welding properties and superior fracture toughness and corrosion resistance to meet the demands of the extreme environments of launch and recovery, including high aerodynamic heating and final seawater immersion. The laboratory is well equipped to perform metallurgical research in the areas of metals processing, mechanical testing, corrosion control, and alloy development. The metals-processing equipment includes foundry, heat treatment, and various metalworking facilities with the capability of casting and finishing experimental melts up to 50 lbs of iron or nickel alloys. The mechanical testing equipment includes tensile, fatigue, and creep machines operating in various programmable load ranges up to 600,000 pounds static and 150,000 pounds dynamic, at test-specimen temperatures ranging from  $-423^{\circ}\text{F}$  to  $2000^{\circ}\text{F}$ , and in various environments including high-pressure gaseous hydrogen. Improvements currently being implemented include a central automatic data-processing system and the development of a second high-pressure environmental test chamber with elevated temperature capability for tests in gaseous hydrogen, hydrogen sulfide, hydrogen-rich steam, and ammonia. Corrosion-control equipment includes test facilities for environmental exposure to a variety of atmospheres, corrosion-fatigue equipment, electroplating facilities, and instrumentation for a wide range of electrochemical studies. Various analytical tools, such as the transmission electron microscope, scanning electron microscope with energy dispersive X-ray

analysis, Auger Spectrometer, and X-ray diffraction equipment, are available in addition to the standard metallographic facilities.

General areas of interest in metallurgical research include linear and nonlinear fracture mechanics, effects of hostile environments on mechanical properties, alloy development, characterization of advanced materials, development and optimization of advanced metals-processing methods, and technique for evaluation of corrosion phenomena and corrosion-control methods. The following are typical of current activities in metallurgical research: effects of high-pressure hydrogen on mechanical properties, including the determination of transition compositions where degradation begins in selected alloy systems; alloy-improvement studies in the nickel-copper alloy system; dimensional stability of alloys after thermal-cycle exposures; effect of various biaxial stress distributions on the ductility of a nickel alloy in gaseous hydrogen; studies on superplasticity in selected commercial alloys; thermal fatigue studies on solar-cell connections; corrosion fatigue of high-strength nickel alloys; an evaluation of the stress-corrosion susceptibility of high-strength steels and aluminum alloys, retained austenite measurements in bearing steels; development of single-crystal turbine-blade materials; and improved bearing alloys for application in advanced turbopumps.

#### **Polymer Science**

W.J. Patterson

44.70.62.03

Polymers fulfill critical functions in space components and hardware, typified by the numerous applications of rigid plastics, synthetic rubber, structural adhesives, electrical and thermal insulations, composite materials, and similar products. During the SATURN program, this laboratory pioneered in the development and utilization of cellular plastic thermal insulations and structural adhesives. The extension of this technology to the SPACE SHUTTLE imposes in some cases the dual additional requirements of elevated temperature stability and reuse capability. Current research interests encompass the following specific areas: preparation, characterization, and study of novel polymers with improved thermal, mechanical, dielectric, or environmental performance characteristics; the development of improved methods of accelerated life testing and prediction based on rheological, dielectric, and mechanical parameters; elucidation of polymer structural and morphological features that contribute to specific attributes, such as low-temperature flexibility, film-forming and adhesive characteristics, UV resistance, and other desired features.

Facilities and equipment are available for the preparation, purification, analysis, and characterization of intermediates; the preparation of test and prototype end items; and the mechanical and dielectric testing of polymer test configurations in diverse environments.

#### **Space Environmental Effects**

A.F. Whitaker

44.70.62.04

As NASA missions progress toward longer operational lifetimes in space, the degradation effects of the space environment on materials and components



become of increasing concern for the survivability of spacecraft systems, while simultaneously the material requirements become significantly more demanding and challenging to meet. The objectives of this laboratory in the research area are to perform real-time and accelerated testing and evaluation, develop accelerated testing methodology, investigate basic and synergistic damage mechanisms, develop theoretical models for material life prediction, develop environmentally stable advanced materials, and provide a design data base for space-systems development.

Research studies are conducted to identify changes in the physical, chemical, electrical, and optical properties of materials induced by environmental insult; to define degradation mechanisms by which the environmental parameters interact with the materials; and to correlate the data with interaction-degradation-prediction models. Specific materials currently requiring characterization are the composite materials, both the fiber-resin composites (graphite-, boron-, and Kevlar- fibers in -epoxy or -polyimide resin) and the fiber-metal matrix advanced composites (graphite-aluminum, graphite-magnesium, boron-aluminum); the polymeric fibers (Kapton, Mylar); optical (Al/MgF<sub>2</sub>, Al/SiO<sub>2</sub>) or thermal (Al, Si, Ti, Zr oxide pigments in inorganic KSiO<sub>2</sub> or organic acrylic or silicon binder) control coatings; glasses (silica); and insulations (MLI).

A component requiring extensive research is the high-efficiency solar cell, especially in the low-temperature low-light-intensity space environment.

The laboratory irradiation facilities are located in several buildings with the electron/proton Van de Graaff accelerators all in the Radiation Effects Facility. Solar irradiations are done with X-25, X-75, and X-200 solar simulators in associated vacuum chambers that range from 1 to 40 ft in diameter. Measurement systems include thermal-vacuum weight loss, volatile condensable materials (VCM), residual gas analysis (RGA), linear variable displacement transformer (LVDT) creep, tensile and elongation, optical spectral transmission and reflectance, and solar-cell electronic load-test apparatus. This equipment base is being updated and expanded to meet new requirements as they are generated to develop and qualify materials and components for the future programs of NASA.

### **Welding Research**

A.C. Nunes, Jr.

44.70.62.05

The Materials and Processes Laboratory maintains a facility for welding research to assist contractors with manufacturing problems, to promote useful technological innovations, and to study fabrication techniques suitable for use in the space environment. Welding equipment—ranging from parallel-gap and stitch welders suitable for assembly of electronic equipment to a 42-kw electron-beam welder capable of penetrating inches of superalloy—are available for research. The welding facility is backed up by facilities for metallography, chemical analysis, and miscellaneous testing, including Gleeble testing, in which rapid heating and cooling programs can be combined

with a programmed stress sequence to study the effect of welding temperature/stress histories on the properties of metals.

General areas of research center around computer modeling of heat-flow and/or weld-puddle dynamics that control material properties and defect formation in the vicinity of the weld and the relation of weld-strength properties to weld structure. Typical recent or anticipated studies are weld geometry strength effect in 2219-T87 aluminum, microfissuring in Inconel 718, depth fluctuations (spiking) in partial-penetration electron-beam welds, weld-puddle physics, two-parameter computer model of welding arc and beam penetration, parallel-gap welding of solar cells, and comparison of variable polarity-plasma arc-weld processes with gas-shielded tungsten-arc welding. An electron-beam welder has been operated in space (a SPACELAB experiment). Considerable industrial interest has been shown in the MSFC two-parameter weld-penetration model.

The light-but-strong requirement for space structures and the catastrophic consequence of failure present a powerful impetus for understanding of the details of weld processes and for the transformation of the art of welding to a science.

#### **Robotic Welding Sensor**

A.C. Nunes, Jr.

44.70.62.06

Application of robots to welding of Shuttle structural components presents many interesting and challenging problems in positioning of the torch, control of the weld parameters, and monitoring of the system variable. The complicating factors are sensor performance in the intense thermal environment of the weld and the size and location of the sensor relative to the weld. A research effort is necessary to address each problem individually and as a system, in order to develop an optimized approach to sensing the required phenomena and feedback system, and to use the information to enhance welding on the Shuttle structural elements and their predecessors.

### **Space Science Laboratory A.J. Dessler, Director**

The Space Science Laboratory conducts theoretical and experimental research in the space sciences, initiates and develops scientific flight experiments, and provides scientific support for the spaceflight projects being developed at MSFC. Major areas of theoretical and experimental emphasis are described in the paragraphs that follow.

#### **Astrophysics**

M.C. Weisskopf G.J. Fishman R. Elsner

44.70.90.01

T.A. Parnell C.A. Meegan

Opportunities for postdoctoral research in the field of X-ray astronomy exist in two broad categories. One category emphasizes scientific data analysis

and interpretation of X-ray observations obtained with the UHURU, SAS-3, HEAO-1, and HEAO-2 (Einstein) satellites. Specific studies currently in progress concern the time variability of galactic X-ray sources. This research requires a background in theoretical astrophysics and data analysis. The second category emphasizes laboratory work leading to the development of sounding rocket and satellite payloads. In addition, a laboratory research program studying the X-ray scattering properties of various materials that may be used for the AXAF X-ray telescope is also in progress.

Opportunities for research in gamma-ray astronomy emphasize the study of transient gamma-ray sources and gamma-ray bursts using large-area scintillation detectors. Balloon-borne instruments are used for these studies, and an advanced detector system for the Gamma Ray Observatory is being developed. Studies of the gamma-ray background and the limitations it imposes on balloon-borne and satellite-borne gamma-ray observations are being pursued.

Cosmic-ray research includes measurement of the chemical composition and energy spectra of nuclei above 10 TeV and studies of nuclear interactions at these energies. Large-volume emulsion chambers coupled with electronic counter systems are flown on balloons.

Opportunities are available in the experimental program, analysis and interpretation of the data, cosmic-ray propagation models, and simulation of particle cascades from heavy nuclei.

#### **Infrared Astronomy**

R. Decher E.W. Urban P.N. Peters C.M. Telesco 44.70.90.02  
Current emphasis in the program in Infrared Astronomy is directed toward the development of a superfluid helium-cooled infrared telescope for the second Spacelab mission, characterizing and understanding the properties of superfluid helium in the near-zero "g" environment, and defining and developing techniques for efficient cryogenic refrigeration and liquid-helium storage applicable to advanced space experiments. Other research areas include the development of improved infrared sensors and astronomical observations and applications of related theory. Subsequent to the second Spacelab flight, opportunities will be available to participate in the analysis of the flight data and the definition of future flight experiments.

#### **Magnetospheric and Plasma Physics**

C.R. Chappell D.L. Reasoner L.R. Lyons 44.70.90.03  
N.H. Stone G.R. Swenson J.L. Green

This research is centered around the study of plasma processes in the Earth's magnetosphere. Particular emphasis is placed on the characteristics of the low-energy thermal plasma of the plasmasphere and ionosphere, the medium-energy plasma responsible for auroral phenomena, interactions between these plasma populations, and the resulting effects on the upper atmosphere. Both flight experiments and laboratory simulation experiments are conducted.

In the flight experiment program, activities include the design, development,

and calibration of the flight instrumentation and the analysis and interpretation of the resulting data. The flight program includes experiments on unmanned satellites and on SPACE SHUTTLE flights. This group is heavily involved in developing plasma and optical instruments to be flown a SPACELAB payloads.

A "plasma wind tunnel" is operated to study various aspects of the satellite-ionosphere interactions. Ionospheric plasma parameters are simulated in the facility, and wake and sheath effects of bodies in the streaming plasma are studied. The plasma chamber is used also to study the plasma around bodies, such as comets and planets, in space.

Ground-based remote-sensing observations of visible auroral emissions are being performed. Theoretical examination of the measured emission intensities and line shapes is conducted to develop an understanding of upper mesospheric and thermospheric processes. Chemical reaction rates, temperatures, and winds are some of the phenomena investigated by these measurements.

#### **Solar Physics**

E. Tandberg-Hanssen	E. Hildner	44.70.90.04
M. Hagyard	R. Moore	

Solar physics research ranges over satellite-experiment data analyses, particularly in Solar Maximum Mission (SMM), theoretical studies, and ground-based observations and analyses.

Current areas of endeavor in theoretical research include magnetohydrodynamic modeling of active solar events, such as solar flares; modeling of surge and spray events and flare-triggering mechanisms; emission-line profile analysis; radiative transfer with magnetic fields; and numerical methods for data analysis. Coordinated ground-based solar observations are made by H-alpha and white-light telescopes and a real-time vector-solar magnetograph. These instruments support ongoing satellite programs and are used as research tools on specific investigative projects both within the Marshall Center and in cooperative research with investigators at other institutions. A key element in the analysis effort is the Center's Image Data Processing Facility, a hardware/software interactive system that allows the scientist-user to control the application of various restoration, enhancement, and analysis programs, which are in turn supported by an IBM 360 host computer. Opportunities for research are provided by the above-mentioned theoretical studies and ground-based facilities and by the SMM, which includes a high-resolution ultraviolet spectrometer/polarimeter experiment capable of measuring intensities, velocities, and polarization between 1200 and 3000 Å. Principle-Investigator responsibilities for that instrument and the ongoing data analysis effort reside within the Center's solar group.

#### **Fluid Dynamics**

W.W. Fowles	44.70.90.05
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The fluid-dynamics research conducted in support of the turbulence studies is an element of a more extensive program treating the dynamical behavior

of fluids. Of particular interest is the behavior in a low-gravity environment. A well-equipped laboratory providing capability for sophisticated flow visualization is available for fluid research. Problems currently being most intensively investigated have arisen either from the requirement to provide fundamental support to already approved spaceflight experiments or from theoretically derived results that appear amenable to test through future SPACELAB experiments. The program is broadly structured to provide support to other areas of research requiring specific investigations in fluid dynamics, while also embracing fundamental studies contributing to an expansion of the basic knowledge in the field.

#### **Separation and Purification of Biological Materials**

R.S. Snyder

44.70.90.06

An opportunity exists to conduct research in the separation and purification of biological cells and proteins to develop basic understanding of the separation phenomenon. Processes commonly used to isolate and purify biological materials are not universally satisfactory in producing the resolution or quantity needed for biological research or clinical use. Often the technique is not sufficiently characterized to permit unequivocal identification and quantification of the factors influencing success.

The proposed research should plan to analyze the fundamental behavior of a separation process by theoretical and/or experimental methods. Proposed experimental investigations need not require the low-gravity environment of space.

The Marshall Space Flight Center's current laboratory capability and interest are in electrophoresis and isoelectric focusing in both static and flowing modes. Experience with other methods and systems is desirable. The applicant should have a strong background in biophysics and biochemistry and should have laboratory experience in separating biological cells or proteins. The Space Science Laboratory's program in fluid dynamics is available to support this research.

#### **Crystal Growth of Solid-Solution Semiconductors**

S.L. Lehoczky F.R. Szofran

44.70.90.07

Research is being done to improve the crystal growth of bulk, solid-solution semiconductor materials. Current emphasis is on the growth of mercury cadmium telluride by directional solidification methods such as the Bridgman method. While having a goal of technological significance, the research is broad in scope and fundamental in nature. Basic materials property measurement in both the solid and liquid states are emphasized, and their relationships to material handling and processing methods are investigated. The role of gravity in the crystal-growth process is of particular interest, and the Research Advisors are the Principal Investigator and a Co-Investigator on an approved spaceflight experiment to investigate that role. Well-equipped laboratories include several types of bulk crystal-growth facilities, electrical and metallurgical characterization equipment, electron microscope with energy

dispersive X-ray analyzer, ultrasonic apparatus, transparent furnaces, differential thermal analysis, X-ray diffraction, Raman spectroscopy, and an electrodeless electrical resistivity measurement system. Computational and modeling efforts are a part of this research and could support any experimental work carried out in the realization of this opportunity.

**Systems Dynamics Laboratory**  
**G.F. McDonough, Director**

The Systems Dynamics Laboratory conducts research in aerodynamics, aerothermodynamics, structural dynamics, vibroacoustic response, control theory, simulation techniques using hybrid and analog computers, and related sciences as applied to launch and space vehicles. Experimental programs include jet-plume investigations in launch and orbital environment, vehicle-base heating from multiengine jet plumes, aerodynamic investigations at very high Reynolds numbers and of cross-flow vortices on bodies of revolution at large angles of attack, and investigations of aerodynamic and engine noise. Theoretical programs of the Laboratory include studies in the following areas: flight dynamics in atmospheric and exoatmospheric environments, including ascent, orbital, and entry; active and passive devices for attitude control; dynamic-loads analysis; oscillations of partially constrained fluids in tanks and other nonlinear vibrational problems; aerodynamics of high and low jet plumes, aerodynamics and thermodynamics of spacecraft in hypersonic rarefied gas flows; flutter analyses and response of tall vehicles to wind; vibroacoustic response techniques; and systems analysis, including the dynamic interaction of subsystems. Support for these research programs is provided by aerothermodynamic test laboratories that include a bisonic wind tunnel, a trisonic wind tunnel, a Ludwig tube tunnel, a thermoacoustic jet laboratory, a low-density chamber, and a special-impulse base-flow laboratory which is used for the study of nozzle flows under actual burning and at altitude conditions. Theoretical and experimental research is greatly enhanced by the ready access to digital, hybrid, and analog computers located at the center.

**Space-Vehicle Dynamic-Response Techniques**

R. Ryan

44.70.99.01

Response analysis of dynamic systems presents many interesting and challenging problems in structural modeling, environment prediction, systems describing equations formulation or simulation, and the statistical treatment of the system parameters. The complicating factors are the large number of degrees of freedom, extensive sets of system parameters, and the large number of cases required to insure a design with a quantified probabilistic statement. The problem is further aggravated if parameter variation must include the structural-dynamic modes or if they include interdiscipline effects, such as structural fluid coupling, control system coupling, and/or structural

acoustic coupling. This results in an excessively long design-loads cycle (roughly one year) and computer costs. Design modes are therefore not a part of systems-verification analysis for approximately one year after incorporation. The objective of this research is to develop modeling techniques for interdiscipline coupling and statistical combination of vehicle parameters to reduce substantially the analysis and computer time required to develop sets of design data. Of particular interest will be the application of the developed techniques to space-station trade studies.

#### **Rotor-Dynamics Analysis for High-Pressure Pumps of the Space Shuttle Main Engine**

L. A. Schutzenhofer

44.70.99.02

Liquid-propellant rocket engines currently in use or planned by NASA require high-speed turbomachinery to generate the necessary high pressures and flow rates. Flexibility of cases and rotors, as well as damping and spring forces of bearings and seals, must be considered in the designs. The shaft speed of such machines typically operates above several criticals caused by flexibility. Several opportunities for research exist in the turbomachinery-analysis area, including modeling of nonlinear rotor friction, modeling of hydrodynamic forces on impellers, devising mathematical means of reducing and interpreting simulation and test results, designing tests to determine model data and coefficients, and further improvement of the damping effect of seals and other components.

#### **Fluid Dynamics**

G. Fichtl

44.70.99.03

Fundamental and applied research opportunities exist for developing extensive experimental, theoretical, and computational programs leading to the development of models and computer codes for use in a wide variety of aerospace engineering and geophysical scientific problems. Problems involving fluid behavior under a variety of forces and under low-gravity environments provide many challenging research opportunities. Numerous small- and large-scale computer facilities are available to support research projects. Full-scale and laboratory support for experimental fluid dynamics studies is also available. Research areas of interest include dynamics of compressible and incompressible liquids and gases, dimensional analysis, dynamic similarity, flow in pipes and through pumps, rarefied gas aerodynamics, geophysical fluids, and computational fluid dynamics.

#### **Atmospheric/Climate Modeling**

W.W. Vaughan R.E. Smith O.E. Smith

44.70.99.04

Research includes theoretical and analytical work aimed at developing improved deterministic and statistical models that permit a predictive capability of the behavior of the Earth's atmosphere with respect to those components of behavior having practical engineering applications, e.g., atmospheric density, pressure, and circulations. Extension of the "standard-atmosphere"

concept to a global time-dependent model is a current project. Analysis of meteorological satellite data to develop inputs for short- and long-term models is an area of emphasis. Extensive files of worldwide atmospheric measurements are available.

#### **Severe-Storms and Mesoscale Research**

H. Christian B.J. Anderson

44.70.99.05

The objective is to understand better the atmospheric processes leading to the development of severe-weather phenomena, the role of microphysics, the role of atmospheric electricity, the interrelationship of atmospheric scales of motion, and the role satellite technology can play in providing both the low-gravity environment in which to conduct laboratory experiments and more meaningful observations and measurements. Satellite remote-sensing data, combined with correlative ground-truth experiments, provide the basis for some of this research. Research involves theoretical, analytical, and experimental work, both in the laboratory and in large-scale field experiments/activities. Thermal diffusion chambers, aerosol generators, humidifiers, and ancillary laboratory equipment are available. Research involves thermodynamics, fluid mechanics, atmospheric electricity, mathematics, probability theory, cloud microphysics, and atmospheric physics disciplines.

#### **Large-Scale Atmospheric Circulation and Dynamics**

G.H. Fichtl F. Leslie

44.70.99.06

This research is concerned with fundamental dynamic problems of the Earth's atmosphere, ranging from planetary to frontal scales. Much of the research centers around the design of a spherical baroclinic experimental model of the large-scale atmospheric circulation that has been proposed for SPACELAB flights. This model uses a radial dielectric polarization body force to simulate gravity. (It must be operated in the low-gravity environment of an orbiting vehicle, because the dielectric force is weak and would be overwhelmed by gravity on the Earth's surface.) In order to design this model to investigate precise scientific questions, a considerable number of theoretical, numerical, and experimental problems have to be tackled. This work builds on previous work with laboratory cylindrical-annulus experiments. Fundamental dynamic questions based on quasigeostrophic and semigeostrophic theory and nonlinear interactions are being studied. A computer general-circulation model is being simplified to match the parameters of the SPACELAB experiment.

#### **Turbulence and Atmospheric Dynamics**

G.H. Fichtl D.W. Camp

44.70.99.07

Basic, applied, and experimental research is conducted in laboratory fluid mechanics and in the atmospheric processes associated with turbulence and fluid mechanics. Atmospheric boundary-layer measurement systems, free-atmosphere turbulence sensors, and environmental-dynamics data provide the opportunity for acquisition of data to use in original research studies. Broad aspects of the present knowledge of turbulence and the mathematical



difficulties associated with converting this knowledge into practical use in aerospace vehicle design and atmospheric-transport process studies are considered. Studies include research on relations between probabilistic structure of turbulence and response-exceedance statistics, determination of developing mathematical methods for representing turbulent velocities for both simulation and study of nonlinear effects, nonlinear mechanisms, and the non-Gaussian probabilistic structure of turbulence.

## Index of Laboratory Directors and Research Advisers

Applicants interested in a particular laboratory should write to the Director of the Laboratory. The Director will arrange for appropriate technical personnel, normally the Research Advisers, to communicate with the applicant.

The area code and exchange are (205) 453.

Dessler, A. J., 13	-3105
McDonough, G. E., 17	-3014
Schwinghamer, R. J., 9	-1279
Anderson, B. J., 19	-5218
Bhat, B. N., 10	-5509
Camp, D. W., 19	-2087
Chappell, C. R., 14	-3036
Christian, H., 19	-2463
Decher, R., 14	-5130
Elsner, R., 13	-0110
Fichtl, G. H., 18, 19	-0875
Fishman, G. J., 13	-0117
Fowles, W. J., 15	-2047
Green, J. L., 14	
Hagyard, M., 15	-0118
Hildner, E., 15	-0123
Lehoczky, S. L., 16	-3090
Leslie, F., 19	-2047
Lyons, L. R., 14	
Meegan, C. A., 13	-0117
Moore, R., 15	-0118
Nunes, A. C., 12, 13	-0011
Parnell, T. A., 13	-5133
Patterson, W. J., 11	-3536
Peters, P. N., 14	-5134
Reasoner, D. L., 14	-3037
Ryan, R. S., 17	-2481
Schutzenhofer, L. A., 18	-4711
Smith, O. E., 18	-3101
Smith, R. E., 18	-3101
Snyder, R. S., 16	-3537
Stone, N. H., 14	-0029
Swenson, G. R., 14	-3040
Szofram, F. R., 16	-3090
Tandberg-Hanssen, E., 15	-0027
Urban, E. W., 14	-5132
Vaughan, W. W., 18	-3100
Weisskopf, M. C., 13	-5133
Whitaker, A. F., 9, 11	-4877