



Painting: Neptune and the Fire of Knowledge by Andrew Nottebohm

1991/92 Graduate Student Researchers Program

including the Underrepresented Minority Focus Component



(NASA-IM-101801) THE 1991/92 GRADUATE STUDENT RESEARCHERS PROGRAM, INCLUDING THE UNDERREPRESENTED MINORITY FOCUS COMPONENT (NASA) 101 P
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1991/92
*Graduate
Student
Researchers
Program*

*including
the Underrepresented
Minority Focus Component*

University Programs Branch
Educational Affairs Division
NASA Headquarters
Washington, DC 20546

NASA
National Aeronautics and
Space Administration

Preface

In 1980, NASA initiated the Graduate Student Researchers Program in order to cultivate additional research ties to the academic community and to support promising students pursuing advanced degrees in science and engineering. Since then, approximately 1,000 students have completed the program's requirements while making significant contributions to the nation's aerospace efforts. In 1987, the program was expanded to include the Underrepresented Minority Focus component. This targeted program was designed to increase minority participation in graduate study and research, and ultimately, in space science and aerospace technology careers. Approximately 176 minority students have earned advanced degrees through this program.

During the next two years, NASA will select at least 230 new Graduate Student Researchers to receive stipends and to work at our unique national laboratories. We are pleased to offer these programs and hope students and faculty will continue to benefit from them.

Special Note: This booklet should be used for both the 1991 and 1992 graduate programs.

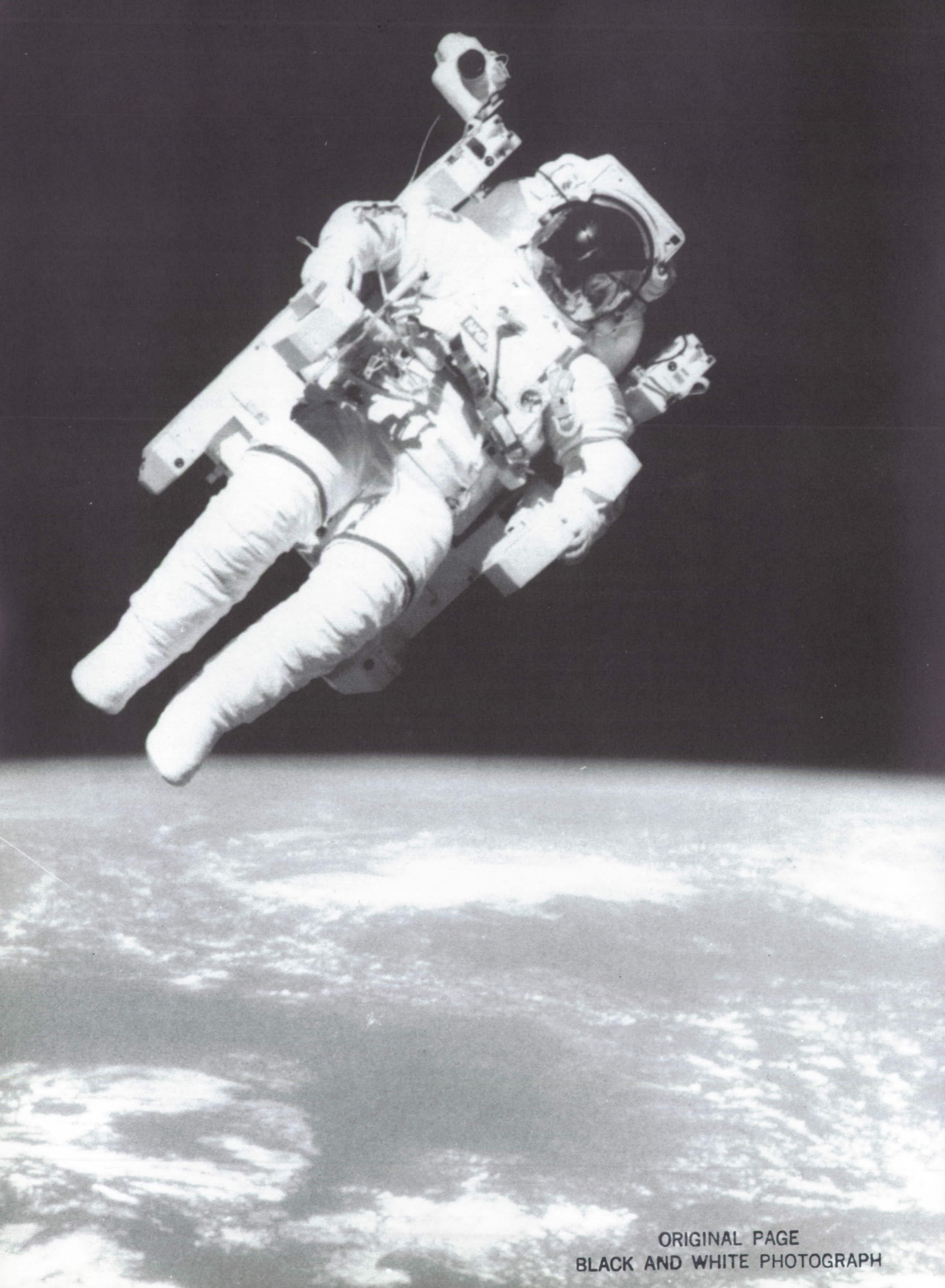
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*Section I—
Introduction*

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Program Summary

Graduate Student Researchers Program (Section II)

The NASA Graduate Student Researchers Program (GSRP) attempts to reach a culturally diverse group of promising U.S. graduate students whose research interests are compatible with NASA's programs in space science and aerospace technology. Each year we select approximately 80 new awardees based on competitive evaluation of their academic qualifications, their proposed research plan and/or plan of study, and their planned utilization of NASA research facilities. Fellowships of up to \$22,000 are awarded for one year and are renewable, based on satisfactory progress, for up to three years. Approximately three hundred graduate students are thus supported by this program at any one time. Students may apply any time during their graduate career or prior to receiving their Baccalaureate degree. An application must be sponsored by the student's graduate department chair or faculty advisor; other eligibility requirements are described in the Administrative Procedures section of this book.

Forty of the 80 new awards each year are sponsored by the Headquarters Office of Space Science and Applications (OSSA) in the fields of astrophysics, communications and information systems, Earth science, life sciences, solar system exploration, space physics, and microgravity science. Students applying for these fellowships are competitively evaluated on their academic qualifications and proposed research and/or plan of study by NASA discipline scientists and an external merit review group. OSSA fellows carry out research or a plan of study at their home universities and attend three day annual symposium at NASA Headquarters in Washington, D.C. The symposium provides an opportunity for GSRP fellows to exchange ideas, discuss progress, and learn more about space science and applications at NASA. OSSA's research opportunities are described in the Areas of Research section of this book.

The remaining 40 new awards are distributed throughout NASA field centers. Fellows selected by centers must spend some period of time in residence at the center, taking advantage of the unique research facilities of the installation and working with center personnel. The projected use of center

expertise and facilities is an important factor, along with academic qualifications and research plans, in the selection of center fellows.

Students applying for a center fellowship are strongly urged to contact the NASA researcher identified at the end of each research description prior to developing a proposal. Students applying to the Headquarters Office of Space Science and Applications may contact Mr. Joseph Alexander's office. See page 15.

Underrepresented Minority Focus Component (Section III)

While we have been very pleased with the success of the Graduate Student Researchers Program, we are concerned that relatively few members of underrepresented minority groups are participating. Thus, in 1987, we introduced the Underrepresented Minority Focus Component. This program component enlists the assistance of university principal investigators on NASA research grants in locating promising graduate students who then compete for NASA support. Students selected for the program will collaborate with university investigators and with NASA technical officers.

Students selected by NASA field centers must spend a period of residency at the center, taking advantage of the unique research facilities of the installation and working with center personnel. As in the Graduate Student Researchers Program, this period may range from several days to several weeks and need not be a single continuous time period. Students selected by NASA Headquarters will be offered an opportunity to work at a field center engaged in related work.

Note: Students attending Historically Black Colleges and Universities (HBCU's) are encouraged to apply to the Graduate Student Researchers Program, but are ineligible for the Underrepresented Minority Focus Component. Graduate students at HBCU's have access to NASA fellowships through other programs between NASA and HBCU's and are directed to these programs sponsored by the NASA Office of Equal Opportunity Programs, Code E, NASA Headquarters, Washington, DC 20546.

Summary of NASA Research Areas

NASA Headquarters (HQ), Office of Space Science and Applications (OSSA)

Astronomy and Astrophysics
 Communications and information systems
 Earth science and applications
 Life sciences

Solar system exploration
 Microgravity science and applications
 Space physics

Ames Research Center (ARC)

Aeronautics
 Experimental aerodynamics
 Computer vision
 Flight research
 Human factors
 Rotocraft technology
 Aircraft conceptual design
 Rotary wing aeromechanics
 Aerophysics
 Artificial intelligence
 Intelligence systems technology
 Aerothermodynamics
 Aerothermal materials and structures
 Computational materials science
 High-speed computer architectures
 Scientific visualization and computer graphics
 Wind tunnel automation
 Wind tunnel composites applications
 Control algorithm for wind tunnel support systems
 Computational fluid dynamics
 Turbulence physics

Unsteady viscous flows
 Applied computational fluid dynamics
 Hypersonics
 Space sciences
 Infrared astronomy and astrophysics
 Theoretical astrophysics
 Life science
 Physical-chemical closed-loop life support
 Bioregenerative life support
 Extravehicular systems research and technology
 Space biology
 Ecosystem science and technology
 Search for extraterrestrial intelligence
 Neurosciences
 Space Physiology
 Solar system exploration
 Planetary biology
 Earth system science
 Earth atmospheric chemistry and dynamics
 Atmospheric physics

Hugh L. Dryden Flight Research Facility (DFRF)

Advanced digital flight control
 Flight systems
 Flight dynamics
 Flight test measurement and instrumentation
 Fluid mechanics and physics

Propulsion/performance
 Structural dynamics
 Aircraft automation
 Integrated test systems and aircraft simulation

Goddard Space Flight Center (GSFC) including Goddard Institute for Space Studies (GISS)

High-energy astrophysics
 Astronomy and solar physics
 Extraterrestrial physics
 Solid Earth geophysics
 Geology and geophysics
 Biosphere studies
 Sensor concepts
 Space geodesy
 Atmospheres
 Space data
 Computations sciences
 Oceans and ice

Severe storms
 Hydrology/water resources

At Goddard Institute for Space Studies:
 Long-term climate change
 Planetary atmospheres
 Biogeochemical cycles
 Interdisciplinary research
 Data systems technology
 Flight dynamics
 Optics laboratory

Jet Propulsion Laboratory (JPL)

Mission design
 Spacecraft system engineering
 Navigation systems
 Mission information systems engineering
 Systems analysis
 Tactical information
 Oceanography
 Earth atmosphere
 Planetary atmospheres
 Earth geoscience
 Planetology
 Space physics
 Astrophysics
 Telecommunications science and engineering
 Radio science
 Gravitational wave studies
 Planetary dynamics
 Asteroid dynamics
 Geodynamics
 Information theory and coding
 Optical communication

Frequency standards research
 Planetary radar astronomy
 Radar remote sensing of the Earth
 Advanced control systems
 Autonomous systems
 Electro-optical tracking systems
 Power research and engineering
 Hypercube
 Flight computers
 Microelectric device research
 Autonomous mobile vehicle
 Robot arm control
 Advanced teleoperation and man-machine systems
 Data storage technology
 Mechanical and chemical systems
 Imaging systems
 Infrared and analytical instrument systems
 Microwave observational systems
 Image processing applications and development
 Optical sciences and applications

John F. Kennedy Space Center (KSC)

Engineering
 Operations research
 Closed ecological life support systems
 Exercise physiology
 Earth sciences

Lyndon B. Johnson Space Center (JSC)

Engineering
 Crew and thermal division
 Tracking and communication
 GN&C systems
 Flight data systems
 Propulsion
 Structures and mechanics
 Systems engineering
 Automation and robotics
 Information systems
 Artificial intelligence

Safety, reliability, and quality assurance
 Risk management
 Space and life sciences
 Biomedical studies
 Biological processing in weightlessness
 Pharmacokinetics research
 Lunar base technology
 Planetary materials analysis
 Orbital debris
 Space radiation

Langley Research Center (LaRC)

Fluid physics
 Propulsion
 General aviation
 High-speed aircraft
 Advanced aircraft systems
 Transport aircraft
 Controls and guidance
 Human factors
 Transport aircraft
 Computer science
 Space controls and guidance
 Materials and structures
 Electromagnetics, antennas, and microwave systems
 Electronic and information system
 Advanced control/display technology
 Optical data storage

Transportation systems
 Spacecraft systems technology
 Structures (space)
 Structures (aero)
 Aeroacoustics
 Advanced sensor systems
 Measurement science and instrument technology
 Materials characterization technology
 Advanced computational capability
 Entry fluid physics
 Power and propulsion
 Transportation systems
 Space systems technology
 Aerodynamics/aerothermodynamic experiments
 Space technology experiments
 Climate research program

Langley Research Center (LaRC) *continued*

Tropheric air quality research program	Configuration definition for the evolution of Space Station <i>Freedom</i>
Upper atmospheric research program	Operation for Space Station <i>Freedom</i> evolution
Nimbus 7/LIMS and SAM II data processing, analysis, and interpretation studies	Subsystem growth requirements for Space Station <i>Freedom</i>
Measurements of air pollution from satellites (MAPS)	Use of CAD/CAE systems in analysis of Space Station <i>Freedom</i> evolution
Stratospheric aerosol and gas experiment (SAGE)	In-space technology experiments
Earth radiation budget experiment (ERBE)	

Lewis Research Center (LeRC)

Aircraft propulsion systems analysis	Advanced composite mechanics
Instrumentation	Liquid rocket propulsion
Controls technology	Low-thrust propulsion fundamentals
Computational fluid mechanics	Rocket engine system monitoring
Experimental fluid mechanics	Photovoltaic space systems
Computational technology	Electrochemical space and storage
Aircraft icing	Space power management and distribution technology
Propeller aerodynamics and acoustics	Power systems technology
Aircraft power transfer technology	Thermal management technologies for space power systems
Turbine engine technology	Solar dynamic systems for space power
High-performance aircraft propulsion technology	Stirling dynamic power systems
Hypersonic propulsion technology	Space environmental interaction
Metal matrix and intermetallic matrix composites	Space power materials
Polymers and polymer-matrix composites	Microgravity science and applications
Ceramic-matrix composites	In-space technology experiments
Microgravity materials science	Space communications systems analysis
Tribology	Space communications components
Structural analysis and life prediction	Satellite communications systems technology
Structural dynamics	Aerospace applications of high-temperature superconductivity
Structural integrity	Lunar/Mars exploration
Probabilistic structural mechanics	

George C. Marshall Space Flight Center (MSFC)

Electrical systems	Structural assessment
Electronics, sensors, robotics	Vibroacoustics
Optical systems	Structural design
Software and data management	Thermal analysis: liquid propulsion systems
Space environmental effects on materials	Thermal analysis: solid rocket motor
Metallic materials research	Thermal/environmental computation analysis
Nonmetallic materials research	Closed loop life support
Processing engineering research	Computational fluid dynamics
Propulsion laboratory	Earth sciences
Component development	Tropospheric wind profiling
Combustion devices and turbomachinery	Stratospheric and mesospheric studies
Control mechanisms	Model studies of storm electrical processes
Magnetospheric and plasma physics	Storm electric field structure
Aeronomy	Cloud scattering of lightning discharges
Solar physics	Climate Modeling with the CMI
X-ray astronomy	Physical climate analysis
Gamma ray astronomy	Geophysical fluid dynamics and modeling
Cosmic ray research	Space vehicle environments
Infrared astronomy	Land surface/atmosphere interactions related to hydrological cycle
Cryogenic physics	Systems analysis and integration laboratory
Low-gravity science	Engineering graphics workstation
Biophysics	Configuration management
Structural dynamics testing	Systems and components test and simulation
Crystal growth in fluid	Mission operations laboratory
Field and Particle dynamic evaluation	Safety, reliability, maintainability, and quality assurance office
Alloying metals and vapor crystal growth evaluations	Reliability engineering
Pointing control systems	Quality engineering
Controls for vehicles	Systems safety engineering
Liquid propulsion dynamic analysis	
Structural dynamics	

John C. Stennis Space Center (SSC)

Life sciences	System analysis and integration
Commercialization	Propulsion
Sensor systems	Information systems/computer science

*Section II —
Graduate
Student
Researchers
Program*

*Administrative
Procedures*



Program Management and Administration

The NASA Graduate Student Researchers Program is managed at the national level by the University Programs Branch, Educational Affairs Division, Office of External Relations, Code XEU, NASA Headquarters, Washington, DC 20546.

Elaine Schwartz
Branch Chief

John T. Lynch
GSRP Program Manager
(202) 453-8344

The Office of Space Science and Applications at Headquarters and NASA field centers participate in the program. Local Program Administrators are:

Mr. Joseph K. Alexander
Assistant Associate

Administrator
(Science and Applications)
Office of Space Science and Applications, Code S
National Aeronautics and Space Administration
Washington, DC 20546

(202) 453-1430
For inquiries call:
Dolores Holland
(202) 453-1523

Mr. Samuel Miller
Mail Stop AHT-241-3
Ames Research Center
National Aeronautics and Space Administration
Moffett Field, CA 94035
(415) 604-6585

Hugh L. Dryden Flight
Research Facility
Edwards Air Force Base
CA 93523
(Program administered by
Ames Research Center)

Dr. Gerald Soffen
Director of University Programs
Code 160
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, MD 20771
(301) 286-9690

Mr. Bill J. Martin
Manager, University Liaison
Mail Stop PT-PAS
John F. Kennedy Space Center
National Aeronautics and Space Administration
Kennedy Space Center, FL 32899
(407) 867-2512

Dr. Harry I. Ashkenas
Mail Stop 183-900
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-8251

Dr. Moustafa T. Chahine
Chief Scientist
Mail Stop 180-904
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-6057

Dr. Stanley H. Goldstein
Director, University Programs
Mail Code AHU
Lyndon B. Johnson Space
Center
National Aeronautics and Space Administration
Houston, TX 77058
(713) 483-4724

Dr. Samuel E. Massenberg
University Affairs Officer
Mail Stop 105-A
Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
(804) 864-2188

Dr. Francis J. Montegani
Chief, Office of University
Affairs
Mail Stop 3-7
Lewis Research Center
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-2956

Dr. Frank Six
University Affairs Officer
Mail Stop DS01
Marshall Space Flight
Center
National Aeronautics and Space Administration
Marshall Space Flight
Center, AL 35812
(205) 544-0997

Administrative Procedures

Selection of Proposals

Graduate students are selected for participation in this program by NASA Headquarters, individual NASA centers, or by the Jet Propulsion Laboratory for participation on the basis of (a) the academic qualifications of the student; (b) the quality of the proposed research or plan of study and its relevance to NASA's programs; (c) except at NASA Headquarters, the student's proposed utilization of Center research facilities; and (d) the availability of the student to accomplish the defined research.

Awards

Awards are made initially for a period of one year and may be renewed annually for up to three years, based on satisfactory progress as reflected in performance evaluations by the faculty advisor. Renewals must also be approved by NASA installation Program Administrators and technical supervisors.

Eligibility

Full-time (as defined by the university) graduate students from an accredited U.S. college or university are the only persons eligible for program awards. They must be citizens of the United States. Students may enter the program at any time during their graduate work or may apply prior to receiving their baccalaureate degrees. All applications must be sponsored by the student's graduate department chair or faculty advisor. Those selected will usually receive support until they receive an advanced degree, a maximum of three years in most cases. An individual accepting this award may not concurrently receive other Federal funds, including that from other Federal fellowships, traineeships, or Federal employment.

Students from under-represented minority groups who apply to this program may also apply to the Under-represented Minority Focus Component (See Section III).

Equal Opportunity

No applicant shall be denied consideration or appointment as a NASA Graduate Student Researcher on grounds of race, creed, color, national origin, age, or sex.

Obligation to the Government

A student receiving support under the Graduate Student Researchers Program does not thereby incur any formal obligation to the government of the United States. However, the objectives of this program will clearly be served best if the student is encouraged to actively pursue research or teaching in aeronautics, space science, or space technology after completion of graduate studies.

Funding

The total award per graduate student cannot exceed \$22,000. In addition to the \$16,000 student stipend, an allowance of \$6,000 (\$3,000 for the student allowance and \$3,000 for the university allowance) may be requested to help defray tuition costs or to provide a per diem and travel allowance for the student and faculty advisor. Student participants and their advisors participating in the Headquarters OSSA program should plan

to attend a three day symposium in Washington, D.C., in the spring of each year. Specific details regarding this conference will be communicated after awards have been made.

The student allowance may also be used to help defray living expenses during periods of center residency. Students currently living close to the center to which they apply should request only a nominal amount for this purpose.

The university allowance may be used by the faculty advisor for supervision of the student's work and for travel to the NASA facility to oversee the student's progress. It may also be used for student tuition. Alternative uses for this allowance may be requested but must be consistent with the intent of the program.

New grant applicants attending workshops/symposiums prior to their grant start date may be reimbursed for travel expenses. The use of training grant funds for purchasing nonexpendable equipment is prohibited.

Preparation and Submission of Proposal

Unsolicited Proposal Requirements

Proposals must be written by the student. NASA does not prescribe a proposal format, but all proposals must be specific in nature and include the information outlined in the following eight items.

1. Proposal Cover Sheet

This page is to be filled out and signed by the graduate student and advisor and included with the proposal. Cover sheet forms appear in the back of this section.

2. Abstract

A short summary describing the objectives of the plan of study and/or the proposed research and the methodology to be used.

3. Description of Proposed Research and/or Plan of Study

A full statement prepared by the student that identifies and relates the key elements of the proposed research and/or plan of study. Length should not exceed five single-spaced pages.

4. Schedule

The proposed starting and completion dates for the graduate student's plan of study and/or research program. The approximate periods the student and faculty advisor expect to be at the NASA center to conduct activities, if applicable. Include a detailed schedule and plan in all new proposals.

5. Facilities and Resources (Center Applicants Only)

A description of the NASA facilities and resources the student wishes to use in support of the research and/or plan of study, including an estimate of any computer time required.

6. Personnel

The faculty advisor should submit a short biographical sketch that includes name, current position, title, department, university address, phone number, and principal publications. The student should submit a transcript of grades and a summary of education, training, awards, scholarships, significant accomplishments, and any other relevant information.

7. Budget

A twelve-month budget must include the following: (a) student stipend — \$16,000 basic stipend for twelve months; (b) student allowance — \$3,000. Cost estimates for tuition expenses and/or anticipated travel and living expenses for the student at a NASA facility; and (c) university allowance — \$3,000. Cost estimates for travel of faculty advisor to a NASA facility to coordinate and

oversee the work of the graduate student. If necessary, student tuition may also be charged against this allowance.

Note — If requesting a renewal, include in the budget the expected amount of unused funds remaining on the ending date of the current grant. Carry over funds must be deducted from the budget.

8. Approval

Approval of proposed research and/or plan of study by (1) the faculty advisor; (2) the department head; and (3) the university official responsible for committing the institution for sponsored research (e.g., Director of Research Administration, Director of Sponsored Research). Proposals are not processed without the appropriate university approval signatures. Telephone numbers should be included for each approving individual.

Equipment

The use of training grant funds for the purchase of non-expendable equipment will not be permitted.

Note: This booklet should be used for both the 1991 and 1992 graduate programs.

Disposition of Unused Funds

If a student terminates the Graduate Student Researchers Program earlier than anticipated, the student stipend is prorated and terminated. Any unused student/ university allowances are returned to NASA.

Submission of Proposal

Applicants should submit 8 copies of all materials by February 1 of each year to the appropriate NASA facility, addressed to the attention of the Program Administrator listed in the Program Management and Administration section of this book. **Headquarters OSSA proposals should be submitted to:**
Graduate Student
Researchers Program
Code SPM-20
NASA Headquarters
Washington, DC 20546

Applications will be reviewed in February of each year for selection in March and April. Proposed starting dates for new awards will be July 1 or after. In general, it is expected that tenure will begin with normal semester or quarter dates.

Sponsored Research Office

When submitting applications for new or renewal fellowship awards, please include the name, address, and telephone number of the university official responsible for committing the institution for sponsored research (e.g., Director of Research Administration, Director of Sponsored Research). The application package should also include certifications to debarment and suspension and the drug-free workplace certification.

Submission for Renewal

Proposals for renewal are to be submitted to the appropriate Program Administrator by February 1. Applicants should submit 8 copies of all materials. The proposal for renewal should include items 1, 2, 4, 7, and 8 listed on the preceding page, as well as a brief statement (approximately one page) by the student outlining his or her progress on the research or plan of study. Also included in the renewal package should be a transcript of the student's grades during the preceding year and a one-page evaluation by the faculty advisor. The starting date for renewals should be on the anniversary of the original grant.

Final Administrative Report

A report on the student's research and academic progress must be submitted by the faculty advisor upon completion of the student's study and research program. Information to be furnished includes the degree

granted, important results of the student's experiences (e.g., thesis title, papers published other than thesis, presentations made, awards, honors), and employment or other future plans. This report should be submitted to:

GSRP Administrator
University Programs
Branch, Code XEU
Educational Affairs
Division
National Aeronautics and
Space Administration
Washington, DC 20546

A copy should also be sent to the appropriate NASA Program Administrator.

Inquiries

Questions concerning the preparation and submission of proposals and the administration of this program are to be directed to the Program Administrators listed on page 15.

PROPOSALS DUE BY FEBRUARY 1

Proposal Cover Sheet, NASA Graduate Student Researchers Program

1. Graduate Student's Name Mr./Ms. _____
Last First MI

Birth Date _____ Birth Place _____ Phone No. _____
Month Day Year

Address _____

2. University _____ 3. Grad Advisor _____

Address _____ Department _____

Telephone _____ Telephone _____

Signature/Date _____

4. Target Degree __MS __MS/PhD (Joint) __PhD 5. Undergraduate GPA _____ Out Of _____

Discipline _____ Discipline _____

6. Expected Completion Date (Mo/Yr) _____ Grad GPA (If Applicable) _____ Out Of _____

7. New Submission ____ First Renewal ____ Second Renewal ____ Designate Grant No. NGT- _____

8. Proposed Starting Or Renewal Date _____
Month Day Year

9. Area of study or proposed thesis or dissertation topic _____

10. NASA Facility To Which This Proposal Is Being Submitted

- | | |
|--------------------------|-----------------|
| Headquarters (HQ) | Kennedy (KSC) |
| Ames/Dryden (ARC/DFRF) | Langley (LaRC) |
| Goddard (GSFC) | Lewis (LeRC) |
| Johnson (JSC) | Marshall (MSFC) |
| Jet Propulsion Lab (JPL) | Stennis (SSC) |

11. Other facilities to which this proposal is being submitted.

12. Name of Proposed NASA Technical Advisor (Center Program Only) _____

13. I certify that I am a citizen of the United States, and am or will be a full-time graduate student at the university during the period covered in the attached proposal.

Signature/Date

In order to determine the degree to which members of each ethnic/racial group are reached by this announcement, NASA requests that the student check the appropriate block(s). Submission of this information is voluntary.

- AMERICAN INDIAN ASIAN* BLACK
- HISPANIC PACIFIC ISLANDER** WHITE
- INDIVIDUAL WITH DISABILITIES***
- MALE
- FEMALE

*This area includes, for example, China, India, Japan and Korea.

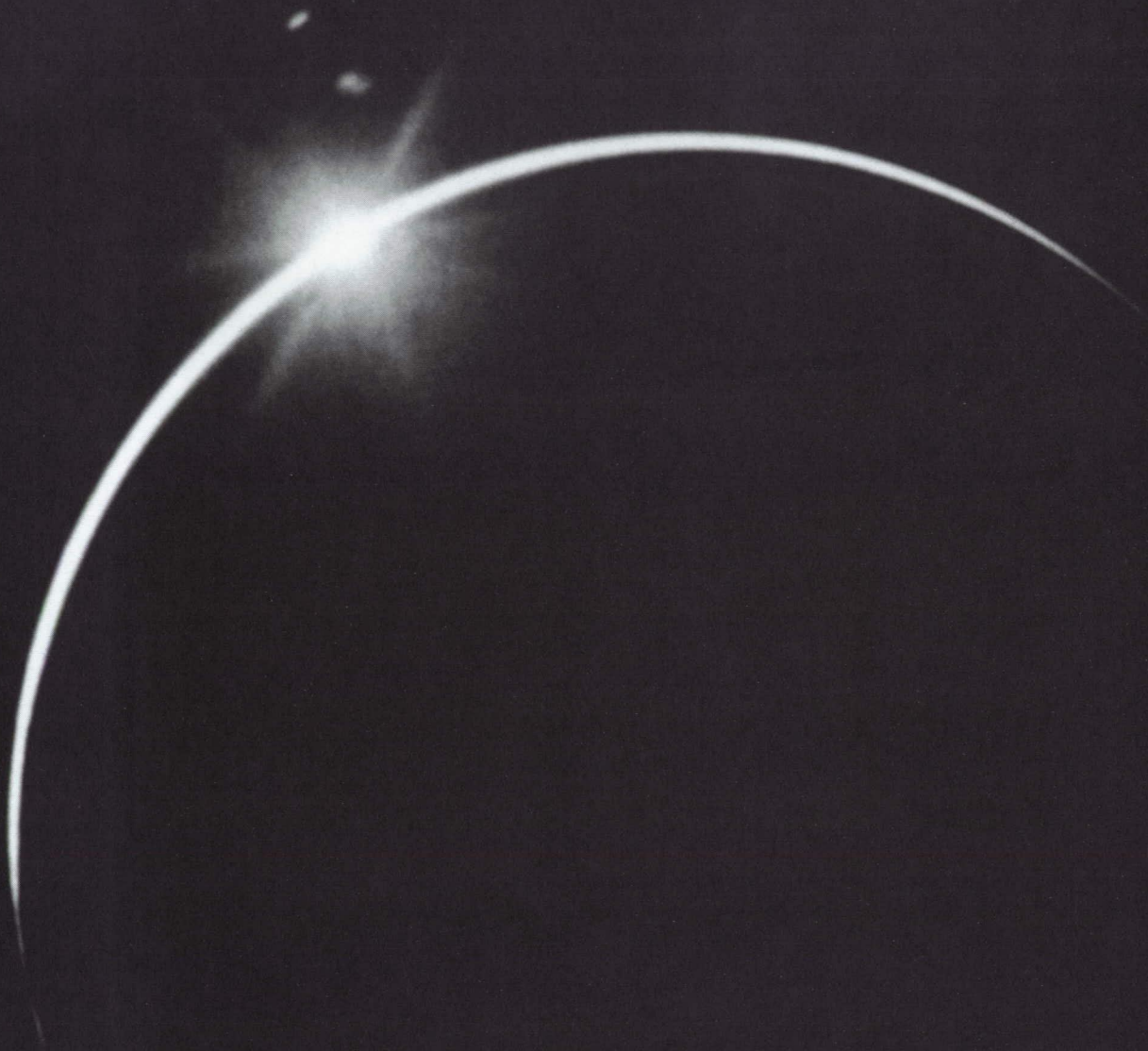
**This area includes any of the original peoples of Hawaii; the U.S. Pacific Territories of Guam, American Samoa, and the Northern Marianas; the U.S. Trust Territory of Palau; the Islands of Micronesia and Melanesia; and the Philippines.

***A disability that limits a major life activity.

*Graduate
Student
Researchers
Program*

*Areas of
Research Activities
at NASA Facilities*

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NASA Headquarters Office of Space Science and Applications

Program Administrator

Mr. Joseph K. Alexander
Assistant Associate
Administrator (Science
and Applications)
Office of Space Science
and Applications, Code S
National Aeronautics and
Space Administration
Washington, DC 20546
(202) 453-1430

For inquiries contact:
Dolores Holland
(202) 453-1523

The NASA Headquarters Office of Space Science and Applications (OSSA) supports the nation's research program in space sciences and the application of space techniques to meet terrestrial needs. The OSSA research program includes the development of major new space flight programs such as the Hubble Space Telescope and the Galileo Jupiter orbiter and probe mission, as well as the support of laboratory research, analysis of data from prior NASA space missions, and theoretical studies of space phenomena. The scientific and applications disciplines currently being supported under the fellowship program are astrophysics, communication and information systems, Earth science and applications, life sciences, solar system exploration, space physics, and microgravity science and applications. A brief description of these programs follows.

Astrophysics

Research in astrophysics involves a broad program in space-based ultraviolet, visible, and submillimeter (UVS) astronomy, relativity, and high-energy astrophysics. Research in astronomy, astrophysics, and relativity is intended to aid in the understanding of the origin and evolution of the universe. UVS research is supported on cosmology, galaxies and quasi-stellar objects, galactic structure, the interstellar medium, and star formation and evolution. This office also supports research in relativity and gravitational wave physics, as well as laboratory research in support of the interpretation of space observations. High-energy astrophysics involves research in all phases of astrophysics involving high-energy processes. Typical of those phenomena are X-ray and gamma-ray emissions from compact binary systems with black hole or neutron star companions, galactic and extragalactic processes that produce high-energy quanta, nucleosynthesis processes, and processes leading to production of primary cosmic ray particles. Experimental and theoretical astrophysics research projects are supported.

Earth Science and Applications

Earth science and applications involves a global, integrated, and interdisciplinary program of research to study the physical and biological processes that govern the solid Earth, its oceans and atmosphere, and its life forms. Particular emphasis is being placed on understanding how the Earth functions as a system and of how it affects and is affected by global change. The program involves coordinated observational, theoretical, modeling, and experimental investigations, and the development of future observing technologies. These activities are complementary and together form a balanced program of system and process studies. The observational investigations usually require use of a variety of instruments making both remote and *in situ* measurements from several locations. Both active and passive techniques are used for remote sensing and covering the electromagnetic spectrum from ultraviolet through the radio wavelengths. Instruments are flown on aircraft, balloons, rockets, orbiting spacecraft, and the Space Shuttle.

Life Sciences

Research in the life sciences involves a multidisciplinary approach to the study of questions related to life in space. In the medical and biomedical sciences, research focuses on issues related to the health and well-being of spacecraft crews and supports the goal of achieving a permanent human presence in space. Areas of emphasis include medical care, space physiology and counter measures, radiation health, environmental health, human factors, and the development of biologically based life support systems. In the biological sciences, NASA's capabilities and technology are used to address fundamental questions related to the origin, evolution, and distribution of life in the universe, the effect of the space environment on life forms, and the ability of terrestrial life to modify the environment on a global scale. Areas of emphasis include exobiology, biospheric research, and space biology. In addition to ground-based research programs, a vigorous flight program to develop and use appropriate equipment and instruments for human, animal, plant, and cellular experiments on board the Space Shuttle, in the Spacelab laboratory module, and on other Earth-orbiting spacecraft is being conducted. Note that proposals in the discipline that require human or animal subjects must contain a statement from the proposer's institution which states that the proposed work will meet all Federal and local human-subject requirements and animal care and use requirements. Policies regarding the protection of human research subjects in NASA-sponsored research are detailed in NASA Management Instruction (NMI) 7100.8B "Protection of Human Research Subjects," and animal care and use requirements are detailed in NMI 8910.1 "Care and Use of Animals in the Conduct of NASA Activities," both of which are available from the Life Sciences Division, Code SB, NASA Headquarters, Washington, DC 20546.

Solar System Exploration

Research in solar system exploration is comprehensive and aimed at understanding the present state of the solar system and, ultimately, its origin and evolutionary processes. The research also aims at elucidating the chemical history of the solar system toward a better understanding of how life originated on Earth. Research takes the form of astronomical observations, laboratory experimentation, space mission data analysis, modeling, and theory. The solar system objects of interest include the terrestrial planets, the giant outer planets with their rings and moons, the asteroids, and the comets. The analysis of meteorites, presumably originating from the asteroids, the Moon, and even possibly Mars, is an essential part of the program. Such analysis now also includes cosmic dust (believed to originate in comets). Astronomical studies span all parts of the spectrum from the ultraviolet to radio and radar. Data analysis includes Viking Mars data, Voyager outer planet data, and data from ground- and space-based telescopes. Data analysis, modeling, and theory encompass all aspects of planetary science including the chemistry, physics, and meteorology of planetary atmospheres; the controlling processes and stratigraphy of planetary surfaces; the internal chemistry and structure of planetary bodies; the dynamics and evolution of planetary ring systems; and cosmology. Most recently, with the advent of new astronomical techniques, research includes the search for planetary systems around other stars.

Microgravity Science and Applications

The objective of the Microgravity Science and Applications program is to develop near-Earth space as a national resource to explore the effects of microgravity on physical and chemical processes and phenomena. This objective includes the establishment of a permanent National Microgravity Laboratory capability in low-Earth orbit to provide a flight facility for conducting long-duration microgravity research. The ongoing research program emphasizes three areas: fundamental science, materials science, and biotechnology. In fundamental science, research includes the study of fluid behavior and transport phenomena in microgravity, as well as experiments that make use of the enhanced measurement precision possible in microgravity to measure physical properties that enable scientists to study and to challenge contemporary theories of physics. Research in materials science includes the processing of electronic and photonic materials; metals, alloys, and composites; glass and ceramics; and polymers. The primary focus of the microgravity program in biotechnology is to study the effects that occur in living organisms and the growth of protein and other macromolecular crystals in the virtual absence of gravity. The investigations are conducted by university, industry, and government researchers using both ground-based and flight experiments.

Space Physics

The space physics program involves investigations into the origin and evolution of plasmas, electromagnetic fields, and energetic particles in a variety of space plasmas and the interactions between those plasmas and atmospheres. Its studies are focused on the Sun, both as a star and as a source of energy, plasma, and energetic particles; on the heliosphere, in both its steady state and dynamic configurations; on

planetary and cometary thermospheres, ionospheres, and magnetospheres; and on the acceleration, transport, and propagation of the solar wind and of solar and galactic cosmic rays. These studies are based on measurements of energetic particles, space plasma systems, plasma processes, plasma-neutral atmosphere interactions, and thermospheric processes which are obtained from *in situ* probes and through remote sensing techniques. Measurements are made from a wide variety of platforms including stratospheric balloons, sounding rockets, Earth-orbiting satellites, missions in orbit around other planets, and the Sun itself, and deep space probes which are approaching the boundary of the Solar System. Theory and computer simulations are used to synthesize these measurements into the general understanding of space physics phenomena, which is the goal of the program.

Communications and Information Systems

The goals of the Communications Program are to maintain U.S. leadership in space communications, enable new and innovative services (NASA scientific, U.S. industry, and public sector needs), and support U.S. and NASA interests in domestic and international regulatory forums. In allowing these goals to be met, specific program objectives have been established: accomplish the timely high-risk research and development of space and ground system hardware and software that will support the U.S. introduction of new and/or improved telecommunications services; apply technical expertise to the domestic and international regulatory and standard setting processes, which support U.S. industry efforts in satellite communications; and define and implement relevant satellite communications systems that contribute to the overall well-being of society.

The Information Systems Program performs a central role in providing information systems services across the OSSA science divisions. Some of the centrally provided services sponsored by the program include providing access to data archives and directories through the National Space Science Data Center (NSSDC) and the NASA Master Directory; providing computer networking services responsive to the communications needs of the widely distributed OSSA scientific research community through two operational networks: the Space Physics Analysis Network (SPAN) and the NASA Science Network (NSN); and providing access to high-performance computing facilities. The program also conducts a

program to apply new information systems research and technology to improve and enhance ongoing support for OSSA science programs. The scope of this program includes development of generic tools and capabilities, testbed efforts to demonstrate and evaluate advanced technologies for application and appropriateness in the NASA environment, technology demonstrations and insertions, and applied research efforts in areas such as graphics and visualization, algorithms, data storage technologies, and access methods.

Submit proposals to:
Graduate Student Researchers Program
Code SPM-20
NASA Headquarters
Washington, DC 20546

Ames Research Center

Program Administrator

Mr. Sam Miller
 Mail Stop AHT 241-3
 NASA Ames Research Center
 Moffett Field, CA 94035
 (415) 604-6585

Ms. Meredith Moore
 Mail Stop AHT: 241-3
 NASA Ames Research
 Center
 Moffett Field, CA 94035
 (415) 604-5624

The Ames Research Center conducts research activities, technology programs, and flight projects to advance the nation's capabilities in both civil and military aeronautics, space sciences, and space applications. This diverse program at Ames is organized into aeronautics, aerophysics, space research, and life sciences.

In preparing a proposal for a fellowship at Ames Research Center, prior collaboration with an Ames researcher is mandatory. A suggested point of contact is listed with each research topic for which a student may apply.

Aeronautics

In aeronautics, Ames concentrates on rotorcraft and powered lift aircraft technology, short-haul aircraft and helicopter technology, fluid mechanics, experimental aerodynamics, flight simulation, flight systems research, and human factors. The following are active areas of aeronautical research.

Contact: Don Ehrreich
 (415) 604-5067

Experimental Aerodynamics — Low-speed testing in the 40-x80-, 80-x120- and 7-x10-foot wind tunnels. Development of computational/empirical prediction methods for powered lift and conventional lift configurations. Prediction and analysis of acoustic characteristics of aircraft configurations and wind tunnel facilities. Development and application of non-intrusive measurement techniques.

Contact: Vic Corsiglia
 (415) 604-6677

Computer Vision — Computer vision and image understanding techniques are being applied to the autonomous navigation of rotorcraft during low-altitude flight. The techniques are quite general and can be used in the autonomous guidance of other types of vehicles.

Contact: Banavar Sridar
 (415) 604-5450

Flight Research — Simulation investigations, guidance and navigation, aircraft automation, flight dynamics, advanced control theory (helicopter V/STOL applications).

Contact: Dallas Denery
 (415) 604-5427
 Guidance & Navigation
 Automation Research
 Vic Lebacqz
 (415) 604-5009
 Flight Dynamics and Controls
 Research

Human Factors — Crew performance, aviation safety, aircraft operating systems, advanced spatial displays and instruments, virtual environments, high-fidelity simulation-based human performance assessment, operator interfaces to intelligent systems and advanced automation.

Contact: Mike Shafto
 (415) 604-6170

Rotorcraft Technology — Rotorcraft development; wind tunnel, simulation and flight test experiments; identification of advanced rotorcraft concepts, technology, and systems integration

Contact: Bill Snyder
(415) 604-6570

Aircraft Conceptual Design — Development of aircraft design synt techniques that incorporate optimization routines, expert system concepts, and graphical user interfaces on a system of networked computer workstations. Studies are broad in nature, encompassing the subsonic to hypersonic speed ranges, and including such concepts as lighter-than-air, rotorcraft, fixed-wing, and transatmospheric vehicles. Analyses include a total transportation systems approach and consider markets and economics.

Contact: Thomas L. Galloway
(415) 604-6181

Rotary Wing Aeromechanics — Experimental and theoretical research programs to improve performance, vibration, and noise of advanced rotorcraft are performed. Studies include basic investigations of the aerodynamics, dynamics, and acoustics of rotor systems for helicopters, tilt rotors, and other advanced configurations. Experiments are performed in the Ames 7- by 10-foot wind tunnel and in the National Full-Scale Aerodynamics Complex, including the 40- by 80- foot wind tunnel.

Contact: William Warmbrodt
(415) 604-5642

Engineering and Technical

Services — In engineering and technical services, Ames concentrates on facility engineering, telecommunications, and administrative computing.

Telecommunications — Engineering and advanced systems capability for voice, video, data communications, and computer networking; networking research.

Contact: Jim Hart
(415) 604-6251

Aerophysics

Artificial Intelligence — Basic and applied research is conducted in the framework of aerospace domains including Space Station Freedom, space science applications, and the proposed Space Exploration Initiative and National Aerospace Plane. Three research areas are emphasized: planning (including both goal- and resource-driven approaches), machine learning (the entire spectrum from empirical to knowledge-intensive), and the design of and reasoning about large-scale physical systems (including work in knowledge acquisition, knowledge base maintenance, and AI applications to the design process).

Contact: Peter Friedland
(415) 604-4277

Intelligent Systems Technology — Research is conducted in high performance intelligent computational systems for aerospace missions. Activities address the unique characteristics of these systems, including autonomous operation, continuous operation, evolutionary capability, real-time performance, and adaptivity. Current research programs include parallel systems (dynamic resource allocation for multiprocessors, multiprocessor performance visualization, parallelization of symbolic applications), fault management (object-oriented fault trees for system modeling, fault monitoring and diagnosis), open computer architectures, analog optical processors for pattern recognition and control tasks, and neural networks. There is also an emphasis on integrating technologies into advanced distributed, heterogeneous systems and developing tools for performance evaluation. Facilities include an advanced architecture testbed, photonic processing laboratory, high-bay space for mockups, and a variety of workstations.

Contact: Donald McKellar
(415) 604-4162

Aerothermodynamics — Provides

aerothermodynamic flow-field computational capability to analyze and design advanced space transportation concepts. Also provides the analytical and turbulence chemistry models required to compute the viscous/finite-rate flow field and to predict radiation heating to conceptual aero-assisted orbital vehicles.

Contact: George S. Deiwert
(415) 604-6198

Aerothermal Materials and Structures —

Develops lightweight reusable ceramics and carbon-carbon Thermal Protection Systems (TPS) for transient, high-velocity atmospheric penetration and develops expendable TPS for planetary probes.

Contact: Howard E. Goldstein
(415) 604-6103

Computational Materials Science — Develops verified methods for predicting material properties and reactions by extending interaction models of interatomic and molecular behavior to the macroscopic level.

Contact: David M. Cooper
(415) 604-6213

High-Speed Computer Architectures — Current advances in high-speed computation are coming from novel computer architectures such as parallel processors, data flow architectures, systolic arrays, LISP/PROLOG architectures. The suitability of these architectures to solving problems of interest to NASA and the development of new architectures that efficiently solve these problems is the objective of this research. Of particular interest is the investigation of architectures to solve problems arising in computational fluid dynamics as governed by the Navier-Stokes equations, problems in computational chemistry as governed by the Schroedinger equation, and problems in automation and robotics such as "expert systems." These investigations could include software issues as well as hardware issues because the ultimate goal is to provide the user the researcher at Ames and at its resident Research Institute for Advanced Computer Science (RIACS) include a CRAY 2, CRAY Y-MP/8128, iPSC/860, Connection Machine 2, and a Sequent parallel computer, as well as numerous superminis and workstations.

Contact: Kenneth Stevens, Jr.
(415) 604-5959

Scientific Visualization and Computer Graphics

Scientific visualization has experienced a rapid growth during the past few years. New developments in visualization have successfully utilized advanced 3-D computer graphics techniques for visual representation of scientific data on a new generation of powerful graphics super-workstations. The growth has also been influenced by an unprecedented demand for visualization tools to analyze and display massive amounts of supercomputer simulation data. The objective of this research is to develop software capabilities for integrated supercomputing visualization environments and to improve preparation, monitoring, display, and analysis of large 3-D datasets from computational physics simulations and experiments. Graphics facilities include SGI-IRIS's, STARTDENT GS-1000, and SUN workstations, frame buffers, animation capabilities, and film recorders. Computational facilities are extensive and include CRAY Y-MP/8128, CRAY 2, Connection Machines CM-2, INTEL IPSC/860, and numerous VAXes. This research will be carried out in conjunction with visualization scientists and computational physics researchers at Ames and at its resident Research Institute for Advanced Computer Science (RISCS).

Contact: Arsi Vaziri
(415) 604-4799

Wind Tunnel Automation — To support an automation project encompassing the automatic control of model positioning, Mach number, Reynolds number, and system safety monitoring, a computer model of the wind tunnel circuit response to various inputs is needed. The model must be generic in structure with easily tailored modules to achieve the required specificity. The task will include surveying industry for applicable programs before full development is undertaken. The code will allow the user to input the dynamic response of various inputs (i.e., total pressure, drive system, model positioning).

Contact: Daniel Petroff
(415) 604-5850

Wind Tunnel Composites Applications —

Transfer to composite technology to specific application for the Aerodynamics Division wind tunnels. Areas of application include: axial flow compressor blading, gaging for model support

assemblies, and siting assemblies for model supports. Research opportunity exists to develop a computer design code for evaluating and tailoring composite structures to the specific application. Opportunity also exists in developing fabrication and QA techniques.

Contact: Daniel Petroff
(415) 604-5850

Control Algorithm for Wind Tunnel Support Systems — Develop and verify the control algorithm and software for a six-degree-of-freedom Captive Trajectory System. The system will be used in wind tunnel testing to evaluate the aerodynamics of separating vehicles. The task involves using existing support systems to accurately and safely position the vehicles for acquisition of data, specifying the control hardware, writing the software, and verifying the software.

Contact: Daniel Petroff
(415) 604-5850

Computational Fluid Dynamics — Theoretical research in fluid dynamics using the Euler and the Navier-Stokes equations, both compressible and incompressible. Includes research on basic equation formulations, algorithm development, and code efficiency, as well as the physics of laminar and turbulent flow fields.

Contact: Thomas H. Pulliam
(415) 604-6417

Turbulence Physics — Study of the fundamental physics of turbulent and transitional flows through numerical simulations. Studies include developing numerical algorithms suitable for direct and large-eddy simulations of turbulent flows, developing tools for analyzing computer-generated databases, and developing turbulence models for engineering applications.

Contact: John Kim
(415) 604-5867

Computer Graphics Workstations — High-performance computer graphics workstations applied to the visualization and understanding of both experimental aerodynamic flow fields and computer-generated solutions of aerodynamic flow fields.

Contact: Val Watson
(415) 604-6421

Advanced Instrumentation — Instrumentation techniques are being developed to measure both mean and fluctuating quantities in complex turbulent flow fields. These include three-dimensional LDV systems, rapid scanning LDV systems, multiple hot wire arrays for spacial and time-dependent data, and holography and methods to measure surface skin friction.

Contact: Joseph G. Marvin
(415) 604-5390

Unsteady Viscous Flows — Research areas under investigation include dynamic stall control, drag reduction on airfoils and wings, and the control of supersonic transition. Experimental, computational, and theoretical tools are developed and used in both basic and applied studies.

Contact: Sanford Davis
(415) 604-4197

Applied Computational Fluid Dynamics — This area deals with the development of new computational methodology involving aerodynamic and/or fluid dynamic applications associated with incompressible, subsonic, transonic, or supersonic flight speeds. Computer codes are constructed and evaluated for applications associated with aircraft or aircraft component aerodynamics, rotorcraft aerodynamics, high angle-of-attack flows, unsteady flows, and flows with aeroelastic effects.

Contact: Terry L. Holst
(415) 604-6032

Hypersonics — This area deals with the development of new computational methodology involving aerodynamic and/or fluid dynamic applications associated with hypersonic flight speeds. The physical aspects of this flight regime require emphasis on algorithms/codes with accurate heat transfer prediction capabilities, strong shock capturing abilities and chemical equilibrium and nonequilibrium models for air.

Contact: Thomas A. Edwards
(415) 604-4465

Space Sciences

In space science, Ames concentrates on research directed at enhancing understanding of the origins, evolution, and current state of the universe, the solar system, the Earth, and life. Principle efforts focus on a multidisciplinary approach to research activities in space science and life science. As a federal research laboratory with strong ties to the universities and other government laboratories, Ames brings to the task a small research team approach that applies the skills and interests of the broader science community to these fundamental issues. Particular emphasis in space science is placed on infrared science and climatology, Earth airborne sciences, and the development and application of selected flight projects and areas of space technology relevant to those research needs. The following are ongoing areas of space science research.

Infrared Astronomy and Astrophysics —

Properties of solar system, galactic, and extragalactic objects using their infrared spectra to determine constituents and processes. Development of instrumentation for observations from ground sites and airborne and spaceborne platforms. Conducts laboratory research in support of this science.

Contact: Fred Witteborn
(415) 604-5520
Pat Cassen
(415) 604-5597

Infrared Astronomy Projects and Technology Development —

Research and development is underway on a range of telescope projects and supporting technology areas. Development is conducted for the Stratospheric Observatory for Infrared Astronomy (SOFIA). Opportunities exist in both hardware development and computer simulation. Extensive computer facilities (CRAYs, VAX, and other workstations), as well as state-of-the-art software design tools, are utilized to simulate telescope subsystems, including structures, optics, thermal, cryogenics, and guidance and control. Current research is focused on the integration of the design tools to allow full system simulation prior to SOFIA operation.

The technology tasks include optics, IR detectors, and cryogenics. Advanced mirror materials are studied in a unique low-temperature facility, where interferometric techniques are used to measure optical surfaces at liquid helium temperature. Multi-element IR detector arrays, with extended spectral coverage and large formats, are developed and characterized under simulated space astronomy conditions. Advanced efficiency cooling techniques for space.

Contact: Gary Thorley
(415) 604-5917
Craig McCreight
(415) 604-6549

Theoretical Astrophysics — Star formation, galactic formulation and interaction, interstellar grains, planetary formation, planetary atmospheres, radiative transfer, and computational astrophysics and atmospheric models to model these processes are but a few of the research issues here.

Contact: Pat Cassen
(415) 604-5547

Space Projects — Development of systems and scientific instrumentation with which to explore space and to study biological effects of weightlessness. This includes development of a biological research capability with plants and animals on Space Station Freedom; development of instrumentation to be used on interplanetary flights and atmospheric penetrations; management of the ongoing flights of Galileo's Probe to Jupiter's atmosphere, of the Pioneer Venus Orbiter about its planet, and of the Pioneers 10 and 11 departing the solar system; and the study and advocacy of scientific instrumentation for future spacecraft.

Planetary Science — Research in this area includes atmospheric chemical, radiative, and dynamic models; remote sensing of planetary atmospheres; planet formation models; and the study of planetary ring dynamics.

Contact: Pat Cassen
(415) 604-5597

Life Sciences

In life sciences, Ames concentrates on biomedicine (the effects of the space environment on man and other organisms), extraterrestrial research, and biosystems (the ability to support man in the space environment).

Advanced Life Support — Advanced Life Support at Ames concentrates on the research and the development of technologies required to support human life in space on long duration missions, for example, transits to Mars, and the establishment of bases on the Moon and Mars. The focuses of the work are on technologies for regeneration of life support materials (water, air and food) through both physical-chemical and bioregenerative processes, and on new concepts in space suits and personal life support systems. The programs have strong ties to universities and industry, and utilize a multidisciplinary approach to scientific, engineering and development issues. The following are ongoing areas of Advanced Life Support.

Contact: William Berry
(415) 604-4930

Physical-Chemical Closed-Loop Life Support —

The area physical-chemical life support includes modelling and simulation, system analysis and the development of devices and test-beds. Subsystems studied include those for 1) air regeneration, including CO₂ removal and reduction, and water electrolysis; 2) waste management and processing, including waste stream separation and various methods of waste oxidation, including incineration, wet oxidation and super-critical water oxidation; 3) water purification and regeneration; and 4) atmospheric contamination removal and control.

Contact: Theodore Wydeven
(415) 604-5738
Edwin Force
(415) 604-3755

Bioregenerative Life Support — The focus of the bioregenerative life support area is on the use of plants and algae as processors and producers of regenerated air, water and food in the space environment. Areas stressed include 1) identification of environmental conditions required for

maximal crop plant productivity; 2) development of biological methods for waste water treatment; 3) modelling, simulation and control of system operation; 4) development of flight hardware for evaluation and qualification of crop productivity in space; and 5) application of technologies to development of devices for astronaut's diet enhancement.

Contact: Robert MacElroy
(415) 604-5573
David Bubenheim
(415) 604-3209

Extravehicular Systems Research and

Technology — EVA research and technology programs at Ames Research Center focus on manned EVA systems for application to further NASA missions, including Evolution Space Station, Lunar Bases and Mars Missions. Key system elements include Portable Life Support, EVA Suits and Equipment, Telerobotic Work Aids Interfaces, and Maintenance and Support.

Major issues relating to Portable Life Support Systems are life cycle costs, reliability, logistics and crew productivity. Supporting research activities include (a) thermal control systems, (b) atmosphere control, and (c) monitoring and control.

An objective of research and technology relating to EVA Suits and Equipment is to develop space suit technologies which will meet the environmental requirements for extraterrestrial EVA operations. Technology development activities include (a) pressure suits, (b) gloves and end-effectors, (c) tools, mobility aids and work stations, and (d) automated checkout techniques. The objective of research and technology efforts relating to telerobotic work aids interfaces to achieve compatibility between EVA astronauts and telerobots through a synergistic relationship between the two in performing EVA tasks. Supporting research and technology tasks include (a) information acquisition and display, (b) control systems and artificial intelligence, (c) proximity sensors, and (d) control and command input techniques.

Maintenance and Support technology includes (a) diagnostics concepts, (b) design concepts for improving the ability of the crew to maintain in-space systems, (c) inventory management techniques, and (d) loose item tracking.

Contact: Bruce Webbon
(415) 604-6646

Space Biology — Space biology research uses the space environment, particularly weightlessness, and ground-based space flight simulations to investigate basic scientific questions about the role of gravity in present-day terrestrial biology and the role it has played during the evolution of living systems. The research is divided into the disciplinary areas of biological adaptation, gravity sensing, and developmental biology. Experiments are carried out at the subcellular, cellular, tissue, organ and system levels in differing organisms of the five kingdoms of life.

Contact: Emily Holton
(415) 604-5471

Ecosystem Science and Technology — Interdisciplinary research in ecosystem science and technology looks at the role of life in modulating the complex cycling of materials and energy throughout the biosphere. Intact ecosystems, with particular emphasis on temperate and tropical forests, are examined by remote sensing from aircraft and spacecraft and by field site visits, with subsequent laboratory and computer analysis of the data gathered. Research results may help answer specific environmental questions from outside collaborators as well as contribute to an overall understanding of the couplings among land, water, and atmosphere and life therein.

Contact: Jim Lawless
(415) 604-5900

Search for Extraterrestrial Intelligence — The Search for Extraterrestrial Intelligence has as its goal the detection of intelligent life elsewhere in the universe. The approach is to examine portions of the radio spectrum, using state-of-the-art search systems to detect and confirm signals of extraterrestrial intelligent origin. The present program is largely concerned with the design of the signal processing hardware and algorithms that will permit us to sift through thousands of megahertz of bandwidth in search of artifact signals that may be

only a few hertz wide. The fields of digital signal processing, VLSI design microcoding, statistics, and astronomical aspects of the search are all germane to this effort.

Contact: Bernard Oliver
(415) 604-5166

Neurosciences — Experimental studies in neurosciences examine how the nervous system adapts to environmental conditions encountered in space, how adaptive processes can be facilitated, and how human productivity and reliability in space can be enhanced. In its efforts to elucidate mechanisms underlying adaptation to space, neurosciences research includes the areas of neurochemistry, neuroanatomy, neurophysiology, vestibular physiology, psychophysiology, and both experimental and physiological psychology. Available state-of-the-art research facilities include human and animal centrifuges, linear motion devices, an animal care and use facility, a human bedrest research facility and NASA's Vestibular Research Facility.

Contact: Mal Cohen
(415) 604-6441

Space Physiology — Space physiology studies investigate the effects of space flight on major physiological systems other than the cardiovascular and the central nervous systems. Emphasis is placed on understanding how the human body regulates muscle and skeletal mass in the absence of gravitational loading. Nutritional, neurohormonal, cellular, electrophysical, biomechanical, and biochemical factors involved in the structure and function of the musculoskeletal system are studied to predict the changes expected during prolonged spaceflight, understand the mechanisms involved, and develop ways to control the deleterious aspects of the changes and expedite recovery upon return to terrestrial gravity.

Contact: Alan Hargens
(415) 604-5746

Solar System Exploration — Solar system exploration research defines flight experiments and related data bases and develops analytical concepts and prototype flight instrumentation for the extraterrestrial study of exobiology (history of the biogenic elements, chemical evolution, and origin and early evolution of life). Particular emphasis is

placed on the biogenic elements (C, H, N, O, P, S) and their compounds as they relate to the composition and physical characteristics of the various bodies and materials of the solar system, such as cometary nuclei and comas and planetary atmospheres and surfaces. Experiment and instrument definition studies for Mars, Space Station Freedom microgravity facilities, interplanetary dust particles, and comet sample return are currently being conducted.

Contact: Glenn Carle
(415) 604-5765

Planetary Biology — Interdisciplinary research in planetary biology is aimed at understanding the factors in cosmic, solar system, and planetary development that have influenced the origin, distribution, and evolution of life in the universe and the course of interaction between biota and Earth's surface environments. Hypotheses are formulated and tested by two major approaches: (1) analysis of samples, such as cosmic dust, planetary materials, ancient and recent rocks and sediments, and extant microorganisms, and (2) use of simulation, ranging from laboratory experiments to computer modeling.

Contact: Sherwood Chang
(415) 604-5733

Earth System Science

In Earth System Science, the focus at Ames is to perform and lead research within the disciplines of atmospheric and ecosystem science with particular emphasis on how the biosphere and atmosphere interact to influence the evolution of the Global system on all time scales.

Earth Atmospheric Chemistry and Dynamics

Research in this area includes the development of models and the use of airborne platforms and spacecraft to study chemical and transport processes that determine atmospheric composition, dynamics, and climate. These processes include the effects of natural and man-made perturbations.

Contact: Phil Russell
(415) 604-5404

Atmospheric Physics — Research in this area includes laboratory spectroscopy, and airborne platforms and spacecraft to advance the knowledge and understanding of the physical processes that determine the behavior of the atmosphere on the Earth and other solar system bodies.

Contact: Francisco Valero
(415) 604-5510

Ecosystem Science — Research in this area is directed to advance understanding of the physical and chemical processes of biogeochemical cycling and ecosystem dynamics of terrestrial and aquatic ecosystems through the utilization of aerospace technology.

Contact: Jim Lawless
(415) 604-5900

Hugh L. Dryden Flight Research Facility

Program Administrator

Mr. Sam Miller
Mail Stop AHT 241-3
NASA Ames Research
Center
Moffett Field, CA 94035
(415) 604-6585

Ms. Meredith Moore
Mail Stop AHT 241-3
NASA Ames Research
Center
Moffett Field, CA 94035
(415) 604-5624

The research program at the Dryden Flight Research Facility, Edwards Air Force Base, CA, is administered by the Ames Research Center. The program includes most engineering disciplines in aeronautics, with emphasis on flight systems integration and flight dynamics. The following descriptions identify the current activities relevant to the Dryden program for which qualified students may apply.

Advanced Digital Flight Control — Modeling, simulation, and flight test of distributed control systems. Design criteria and methods for unconventional vehicles, including decoupling of asymmetrical airplanes and stabilization of highly unstable airframes. .
Contact: Kevin Petersen
(805) 258-3189

Flight Systems — Engineering aspects of the formulation, design, development, fabrication, evaluation, and calibration of flight control, avionic, and instrumentation systems used on board complex, highly integrated flight research vehicles. Work with fault tolerant redundant microprocessor-based control systems; microprocessor-based measurement systems; transducers; actuators; techniques for system safety; and hazard analysis.
Contact: Jim Phelps (805) 258-3117

Flight Dynamics — Pilot/aircraft interaction with advanced control systems and displays, assessing and predicting aircraft controllability, developing flying qualities criteria, parameter estimation, and mathematical model structure determination.
Contact: Don Berry (805) 258-3140

Flight Test Measurement and Instrumentation — Laser-based flow measurement, skin friction drag, fuel flow, integrated vehicle motion measurements, space positioning, airframe deflection, sensor and transducer miniaturization, digital data processing.
Contact: Rodney Bogue
(805) 258-3193

Fluid Mechanics and Physics — Laminar and turbulent drag reduction configuration aerodynamics, experimental methods, wing/body aerodynamics, full-scale Reynolds number test technology, high angle of attack aerodynamics, applied mathematics and atmospheric processes.
Contact: Robert Meyers
(805) 258-3707

Propulsion/Performance — Propulsion controls, integrated propulsion/airframe systems, vehicle performance measurement.

Contact: Larry Myers (805) 258-3698

Structural Dynamics — Aerostructural modeling, vibration and flutter analyses/predictions, aircraft flutter, flight envelope expansion, ground vibration and inertia testing, aeroservo/elasticity, active control of structural resonances, advanced flight test technique development.

Contact: Mike Kehoe (805) 258-3708

Aircraft Automation — Knowledge-based systems development, verification and validation of knowledge-based systems, neural networks, heuristic controllers, knowledge-based acquisition/implementation, maneuver controllers, performance optimization, guidance, pilot-vehicle interface, robotic aircraft.

Contact: Lee Duke (805) 258-3802

Integrated Test Systems and Aircraft Simulation — Development of Integrated System Test equipment including aircraft/simulation interface equipment, automated test equipment and applied artificial intelligence techniques for diagnosis and control. Flight simulation development for advanced aircraft systems in aerodynamic, propulsion and flight control modeling.

Contact: Dale Mackall (805) 258-3408

Goddard Space Flight Center

Program Administrator

Dr. Gerald Soffen
 Director of University
 Programs
 NASA Goddard Space
 Flight Center, Code 160
 Greenbelt, MD 20771
 (301) 286-9690

The Goddard Space Flight Center has a variety of programs and activities in pursuit of space exploration. Included are space sciences, earth sciences, space research and technology, space transportation systems, space tracking and data systems, and Goddard's payload operations control centers for Earth orbital operations of free-flyer payloads. The three major areas of Goddard research where the Graduate Student Researchers Program is conducted are in the Space and Earth Sciences Directorate, the Engineering Directorate, and the Mission Operations and Data Systems Directorate. The following is a brief description of research programs for which qualified graduate students may apply.

Laboratory for High Energy Astrophysics

High energy astrophysics is the study of those physical processes in an astronomical setting that typically occur at energies in excess of the few million degree temperatures characteristic of stellar photospheres. Continuum X-ray and gamma ray emission is produced by the interaction of charged particles with matter and electromagnetic fields, so that the study of such radiation is the study of these interactions in remote settings, while cosmic ray studies sample the charged particle distributions locally. Discrete lines in the X-ray and gamma ray spectra can be related to extreme environments in compact objects (ultra-high magnetic fields, for example), and can trace nucleosynthesis through nuclear or atomic transitions. In the Laboratory for High Energy Astrophysics, a broad program of experimental and theoretical research is conducted in all phases of astrophysics that deal with cosmic particles and the high energy quanta that their interactions produce. Experiments that measure cosmic X-rays, gamma rays, and charged particles are designed, built, and flown on balloons, rockets, Earth satellites, and deep space probes. The resulting data are analyzed and interpreted by laboratory scientists and their associates. In so studying the physics of solar, stellar, galactic, and metagalactic high energy processes, theoretical models of the origins and histories of these particles and quanta are developed. Contact:

C. E. Fichtel
 (301) 286-6281
 High Energy (>20 MeV)
 Gamma Rays
 T. L. Cline (301) 286-8375
 Low Energy (.02-20 MeV)
 Gamma Rays
 E. A. Boldt
 (301) 286-5853
 X-rays (.2-20 keV)
 J. F. Ormes
 (301) 286-5705
 Cosmic Rays

Laboratory for Astronomy and Solar Physics

The Laboratory for Astronomy and Solar Physics conducts a broad program of research in observational and theoretical astronomy and solar physics. Observational programs, including technology and instrumentation develop-

ment, span the spectral range from X-ray to radio wavelengths. Astrophysical phenomena of the Sun and stars are studied with emphasis on their structure, origin, and evolution. Investigations on the gross dynamics and transient properties of the atmospheres of the Sun and other stars are carried out, emphasizing phenomena revealed by spectroscopic observations made above the Earth's atmosphere and correlated with ground-based observations. The interstellar medium is studied, both on a large scale to elucidate the distribution of mass and luminosity in the Galaxy and in individual clouds to probe processes of stellar formation, grain characteristics, and cloud chemistry. The Milky Way galaxy, other galaxies, quasars, and radio galaxies are studied, with special emphasis on those parameters bearing on the present structure of the universe as well as on its origin, age, and future fate. The cosmic microwave and infrared background radiations are also studied to probe the early history of the universe. Additional research includes investigations of the chemical history of the Solar System and the nature of the solar wind interaction with comets. Data of interest to laboratory scientists are currently being obtained from the *International Ultraviolet Explorer* (IUE) and the Cosmic Background Explorer (COBE); archival data from these missions, the Solar Maximum Mission, and the *Infrared Astronomical Satellite* (IRAS) are extensively used. The laboratory's High Resolution Spectrograph on the Hubble Space Telescope, as well as the Ultraviolet Imaging Telescope on the Astro Mission, will yield additional data for analysis. The Space Telescope Imaging Spectrograph (STIS) will provide diffraction-limited spectral imagery when installed in the Hubble Space telescope in the mid-1990s. Two missions, Lyman Explorer and High Resolution Solar Observa-

tory are being studied. Conceptual and

technology studies for an Infrared Array Camera on the *Space Infrared Telescope Facility* (SIRTF) are in progress. Active suborbital observing programs are carried out from ground-based, airborne, balloon-borne, and rocket-borne instruments.

Contact:

Theodore Gull

(301) 286-8701

Interstellar Medium

Michael Hauser

(301) 286-8701

Infrared Astronomy

David Leckrone

(301) 286-8904

UV-Optical Astronomy

Stuart Jordan

(301) 286-8811

Solar Physics

Laboratory for Extraterrestrial Physics

This laboratory performs research on the physical properties and dynamical processes active in solar, planetary, and stellar objects, and interplanetary and interstellar media. The chemistry and physics of comets, planetary atmospheres, magnetospheres, and condensed Solar System matter, including meteorites, asteroids, and planets, are studied. A major effort is the analysis of data from *Voyagers* 1 and 2, the one remaining *International Sun Earth Explorer* spacecraft and the two *Dynamics Explorer* spacecraft, including magnetic field, radio wave, electron and ion plasma in the Jovian and Saturnian magnetospheres, Io plasma torus, and Titan.

Infrared spectra of the outer planets are also studied to deduce atmospheric properties. In infrared astronomy, the laboratory studies molecular astronomy, galactic infrared sources, as well as solar and planetary infrared astronomy. Instrumentation includes various diode laser heterodyne spectrometers and in-house developed instruments for use on the ground, in aircraft, and on balloons. Work is continuing on the scientific aspects of the International Solar Terrestrial Physics Program and

the joint ESA-NASA Ulysses Solar Polar mission. Studies on molecules and chemical reactions of astrophysical and aeronomic interest are also conducted in the special facilities of the laboratories. Contact:

Daniel N. Baker
(301) 286-8112
Solar Terrestrial Studies

John Hillman
(301) 286-7974
Infrared Spectroscopy
& Molecular Structures

Louis Stief
(301) 286-7529
Chemical Kinetics

Keith Ogilvie
(301) 286-5904
Fields and Particles

Michael J. Mumma
(301) 286-6994
Planetary Atmospheres

Steven Curtis
(301) 286-9188
Planetary Magnetospheres

James Slavin
(301) 286-5839
Electrodynamics

Laboratory for Terrestrial Physics

The Laboratory for Terrestrial Physics performs research directed at advancing the state of knowledge in the Earth sciences and the management of the resources of the Earth through the use of space technology.

These efforts include solid Earth geophysics, geology, space geodesy and the study of the biosphere.

Objectives are the complete, fruitful utilization of data of the Earth obtained from satellites and the development of future satellite systems that will enable deeper understanding of the Earth system.

Activities include laboratory and field investigations, acquisition and use of data gathered aboard spacecraft and aircraft, and numerical simulation and modelling.

Applicants should discuss potential research programs with the appropriate point of contact.

Calibration Studies - Research is directed at

development of methods and methodologies to track the performance in orbit of sensors such as MODIS for EOS and the AVHRRs for NOAA. Unique tools for these studies include laboratory standards and a sensor which operates on the NASA ER-2 aircraft.

Contact: B. Guenther, Code 920.1

(301) 286-5205

Solid Earth Geophysics — Research topics include the structure and composition of the Earth's interior through geodetic studies of the gravity field and rotational parameters of the Earth and planets, and the dynamics of the measurement of topography with altimeters and studies of planetary landforms.

Contact: L. Walter, Code 921

(301) 286-2538

Geology Geophysics — Research includes studies of the Earth's crust through the use of remote sensing for geologic and coastal investigations and the measurement of crustal magnetic anomalies, as well as at the understanding of the generation of the Earth's main magnetic field.

Contact: J. Heirtzler, Code 922

(301) 286-5213

Biosphere Studies — These include research on the interaction of electromagnetic radiation with plant canopies that permits the remote measurement of biomass and vigor and the study of phenomena such as deforestation and acid rain.

Contact: C. Schnetzler, Code 923

(301) 286-3532

Experimental Instrumentation -

Develops advanced electro-optic and laser sensors for ground-based, airborne and spaceborne Earth and planetary science applications. Work includes laser and detector research, sensor development research and conceptual design, performance calculations, sensor engineering and fabrication, as well as instrument calibration and integration. Sensors are used for measurements of Earth and planetary surfaces and of the Earth's atmosphere and ocean. Develops and manages advanced laser sensors, including laser altimeters and lidar systems, for airborne and spaceborne use.

Sensor Concepts - Studies and analyses are directed toward development of optical remote sensing systems for observing reflected solar and emitted thermal radiation from the Earth/atmosphere system. Research in advanced technologies enables new systems and research in techniques improves the precision of pre- and post-launch characterization/calibration.

Contact: W. Barnes, Code 925
(301) 286-8107

Space Geodesy — Research uses precise geodetic methods, including laser ranging and very long baseline interferometry; altimetry; data from highly accurate tracking systems such as GPS and doppler, gradiometry and satellite-to-satellite tracking; to measure and study the motion of the Earth on its axis, the kinematics of plate motion, the deformation of the crust, the Earth and ocean tides, ocean circulation, and models of the gravity fields of the Earth and planets.

Contact: B. Putney, Code 926
(301) 286-6018

Laboratory for Atmospheres

This laboratory performs a comprehensive theoretical and experimental research program dedicated to advancing our knowledge and understanding of the atmospheres of the Earth and other planets. The research program is aimed at advancing our understanding of the structure, dynamics, and radiative and chemical properties of the troposphere, stratosphere, and mesosphere, and thermosphere, determining the role of natural and anthropogenic trace species on the ozone balance in the stratosphere, and advancing our understanding of the physical properties of the atmospheres and ionospheres of the Earth and other planets. The laboratory identifies problems and requirements for observations of atmospheric processes by satellite and other

techniques. A broad program of laboratory research, including instrument development of mass spectrometers and remote sensing laser detectors, supports the program to observe the Earth and the planets. Extensive computer facilities and interactive processing systems are available for data processing. Contact:

Raymond Bates
(301) 286-7482
Global Modeling and
Simulation

Albert Arking
(301) 286-7208
Climate and Radiation

Richard Hartle
(301) 286-8234
Planetary Atmospheres

Robert Hudson
(301) 286-5485
Stratosphere Chemistry
and Dynamics

Eugene Maier
(301) 286-4425
Solar Radiation

Hasso Niemann
(301) 286-8706
Mass Spectrometry

Harvey Melfi
(301) 286-7024
Remote Sensing

Space Data and Computing Division

The Space Data and Computing Division provides comprehensive research, development, and support in data handling and computing for space and Earth science research programs. The division manages and operates a NASA Supercomputing Center, a National Space Science Data Center, the Science Information Systems Center and an Advanced Data Flow Technology Office all in support of space and Earth sciences. The increasing complexity, variety, and volume of data needed for research in Earth and space sciences require the development and integration of advanced computing tools and techniques.

Contact: Mike Hollis
(301) 286-7591

NASA Center for Computational Sciences

— The center is engaged in the application of advanced computer system architectures, such the CRAY Y-MP and the massive parallel processes such as the MASPAP, to support complex computational physics modeling efforts. These modeling efforts involve, for example, studies of coupled multi-dimensional ocean and atmospheric systems, multi-dimensional magnetospheric-ionospheric systems, and astrophysical processes. Specific research opportunities exist for development of new numerical algorithms in computational physics that utilize advanced computer architectures, development of advanced scientific visualization, algorithms for visualization of space and Earth sciences processes, and the development of advanced techniques for managing deca-terabyte mass data storage and delivery.

Contact: Daniel S. Spicer
(301) 286-7334

National Space Science Data Center

The center offers exceptional opportunities for computer scientists seeking to apply advanced data systems concepts to NASA's challenging space data problems. Areas of interest include Data Base Management Systems (DBMS) heterogeneous multisource data bases, transaction management, and data base logic.
Contact: Barry Jacobs (301) 286-5661

Research is conducted on advanced data systems for scientific data management, using expert systems, data base machines, digital optical disk technology, and computer visualization. Contact:

Bill Campbell
(301) 286-8785
Expert Systems
Jim Green
(301) 286-7354
Data Base Machines
Joseph King
(301) 286-7355
Optical Disks
Greg Goucher
(301) 286-9884
Computer Visualization

Developing interactive scientific data systems integrating data archiving, catalogue, retrieval, data and image manipulation, and transmission techniques into distributed systems, e.g., NASA Climate Data System (NCDS) and Pilot Land Data System (PLDS).

Contact: Blanche Meeson
(301) 286-9282

Science Information Systems Center

In general, this center conducts research in applied computer sciences and information sciences, engineering and integrating results into the data and information systems of advanced space and Earth science satellite sensor missions. Topic areas include the investigation of expert systems approaches to data analysis and information extraction; development of computer perception; development of parallel/concurrent processing algorithms and software and implementation of parallel computing machines such as the Massively Parallel Processor; and application of georeferenced/geocoded information systems techniques to Earth sciences data. Research is also conducted in image data understanding and image data correction methodologies.

Contact: Jim Smith (301) 286-9041

Investigation of expert systems approaches to data analyses and information extraction, particularly space remotely sensed image data.
Contact: James Tilton (301) 286-9510

Development of computer graphics techniques for scientific data visualization and information perception.

Contact: James Strong (301) 286-9535

Development of parallel/concurrent processing algorithms and software, and implementation on parallel computing machines such as the Massively Parallel Processor.

Contact: John Dorband (301) 286-9419

Development of image data processing techniques, including image data correction and georeferencing/geocoding of Earth observed image data.

Contact: Jim Smith (301) 286-8744

Data Flow Technology Office

This office conducts advanced research in the development of network control management systems, computer communications architecture, fiber optics, network computer simulation, and high-speed LAN and WAN network development.

Contact: J.P. Gary
(301) 286-9804

Laboratory for Hydrospheric Process

The laboratory performs theoretical and experimental research on various components of the hydrological cycle and its role in the complete earth system. The program is aimed at observing, understanding, and modeling the global oceans and ice, surface hydrology, and mesoscale atmospheric processes. The laboratory conducts research on earth observational systems and techniques associated with remote and in-situ sensing.

Contact: Franco Einaudi
(301) 286-6171

Ocean Data Systems Office

This office performs research and development of advanced direct readout data acquisition systems, and designs, builds, and organizes large interrelated data bases to increase their usefulness to researchers in the areas of oceans, weather, earth resources, and climate and hydrology. Develops and manages major projects for the remote sensing of the Earth and its environment and implements these projects in support of NASA, NOAA, and USAID programs.

Contact: Charles Vermillion
(301) 286-5111

Oceans and Ice Branch

This branch conducts oceans and ice research to enhance understanding of these systems and their relationships with other elements of the biosphere and the geosphere. Works with the scientific community on problems in biological, physical, and polar oceanography; glaciology; and marginal ice zones and air-sea interactions. Pursues interdisciplinary studies, together with atmospheric and terrestrial scientists, on problems such as those involving the biomass, productivity, nutrient distributions, carbon fluxes, geostrophic and thermohaline circulation of tropical, mid-latitude, and polar oceans, and upwelling and ice sheets. Employs theoretical and numerical modeling methods, develops algorithms and interpretations, and participates in sensor development. Demonstrates, through flight programs and analyses, the uses of remote sensing in research on the Earth environment, global habitability, global biogeochemical cycles, and global change.

Contact: Antonio S. Busalacchi
(301) 286-4718

Observational Science Branch

This branch conducts theoretical and experimental research on observational systems and techniques for oceanic remote sensing. Develops and operates research facilities (i.e., wave tank, laboratory field standards, aircraft remote sensors), ground-based ozone and wind sensors to obtain scientific data and develop new sensors.

Contact: Dave Clem
(804) 824-1515

Severe Storms Branch

This branch performs research on a broad range of meteorological problems ranging from the synoptic scale down to micrometeorology, with emphasis on the initiation and development of weather systems and on measurement of precipitation. Scientists in the branch employ theoretical and numerical modelling methods, observational analyses, and participates in sensor development for the measurement of precipitation.

Hydrology/Water Resources

Activities address the use of remote sensing through advanced numerical and analytical models to measure and define the abundance of water, ice and snow on land surfaces and the exchange of water between soil, biosphere, and atmosphere.

Contact: E. Engman
(301) 286-5480

Microwave Sensors and Data Communication Branch

This branch performs research and development on advanced microwave sensing systems and data collection systems directed at providing remote and in situ data for research in the areas of the oceans, weather, climate, and hydrology. Performs basic laboratory and field studies that elucidate the interaction of electromagnetic radiation with the environment to improve our understanding of remote sensing systems.

Contact: Jan M. Turkiewicz
(301) 286-9831

Goddard Institute for Space Studies (New York, NY)

The Institute for Space Studies conducts comprehensive theoretical and experimental research programs in four major areas.

Causes of Long-Term Climate Change —

Basic research on the nature of climate change and climatic processes, including the development of numerical climate models. Primary emphasis is on decadal or end-of-century global-scale simulations, including studies of humanity's potential impact on the climate. Climate sensitivity and mechanisms of climatic change are investigated in global paleoclimatic research, specifically from the comparison of pollen and glacial data with paleoclimatic model simulations. In addition to their use for climate simulations, the global models are used to simulate the transport of atmospheric constituents and thus study their global geochemical cycles. The program also includes development of techniques to infer global cloud, aerosol and surface properties from satellite-radiance measurements as part of the International Satellite Cloud Climatology Project and the Earth Observing system and analysis of the role of clouds in climate.

Contact:

Anthony Del Genio
(212) 678-5588
Convection and Clouds
James Hansen
(212) 678-5619
Greenhouse Effect
Dorothy Peteet
(212) 678-5587
Paleoclimate, Pollen Studies
David Rind
(212) 678-5593
Climate Dynamics,
Stratosphere
William Rossow
(212) 678-5567
Global Cloud Properties
Andrew Lacis
(212) 678-5595
Radiative Processes

Planetary Atmospheres — Concerned with investigations of Jupiter, Saturn, Venus, and the Earth. The observational phase of the program includes imaging and polarization measurements from the *Pioneer Venus Orbiter* and radiation-budget, temperature-sounding, photometric, and polarization measurements from the *Galileo Jupiter Orbiter*. The theoretical phase of the program includes interpretation of radiation measurements of planets to deduce bulk atmospheric composition and the nature and distribution of clouds and aerosols, and modeling of atmospheric thermal structure and dynamics using both numerical and analytical models. Emphasis in the theoretical program is on analysis of physical processes in terms of general principles and models applicable to all planets. Contact:

Michael Allison

(212) 678-5554

Anthony Del Genio

(212) 678-5538

Atmospheric Dynamics

Larry Travis

(212) 678-5599

Barbara Carlson

(212) 678-5538

Radiative Transfer

Biogeochemical Cycles — Research on global biogeochemical cycles involving the study of chemically and radiatively important trace gases. The aim is to improve our understanding of the cycles of CO_2 , CH_4 , N_2O , CFCs, O_3 , NO_x , OH, and other trace compounds. Many trace gases are observed to be increasing in the atmosphere and are expected to affect climate and air quality in the near future. The research involves three-dimensional chemical tracer models, which are essential for determining the sources and sinks of these gases and for predicting future atmospheric composition. Central to the program is the investigation of the role of the biosphere, terrestrial and oceanic, in the

global carbon cycle using a combination of satellite measurements and modeling. This research is being carried out in cooperation with Harvard University, and with the Applied Mathematics Program and Lamont-Doherty Geological Observatory of Columbia University. Contact:

Inez Fung

(212) 678-5590

Carbon Cycle, Ocean Modeling

Michael Prather

(212) 678-5625

Atmospheric Chemistry

Interdisciplinary Research — Interdisciplinary research ranges from theoretical studies of the origin of the solar system to relationships between the Sun, terrestrial climate, geological processes, and biology. One phase of the program involves the structure and evolution of accretion disks, especially the primitive solar nebula, using models of large-scale turbulence. Another topic is the calculation of molecular properties of atmospheric and astrophysical interest. A third area concerns the evolution and pulsation of bright stars, which may be analogs of the Sun. A biological question of special interest concerns how terrestrial vegetation will change during the next 50 years, when climate and atmospheric CO_2 are expected to be changing. Contact:

Vittorio Canuto

(212) 678-5571

Large-Scale Turbulence

Sheldon Green

(212) 678-5562

Molecular Calculations

Richard Stothers

(212) 678-5605

Stars, Climate Studies

Dorothy Peteet

(212) 678-5587

Biology

Data Systems Technology Division

The Data Systems Technology Division develops and applies systems, hardware, and software technologies to support complex command and control, communications, and telemetry data processing requirements of future space missions. The division performs advanced technology development in high performance VLSI systems for telemetry processing, high data rate/volume data storage architectures, distributed systems and networks, computer-aided software engineering, human-machine interface technology, and artificial intelligence—primarily in the areas of cooperating knowledge-based systems, planning and scheduling, and monitoring and control. Joint projects are formed with other Goddard organizations to transfer technology from the laboratory into operational systems through the development of test beds and advanced operational prototypes. Application projects include VLSI-based telemetry front end processors and workstations, a test bed for distributed mission planning and scheduling, a computer-aided systems engineering support environment, an advanced object-oriented programmer's workbench for user interface design (TAE Plus), an intelligent spacecraft control center test bed, and a prototype self-organizing network for distributed telemetry systems. Division laboratory facilities provide some of the most advanced system design and development capabilities available, including a complete suite of VLSI design tools, libraries, and workstations; advanced commercial parallel disk farms; VME components for system integration; workstations from SUN, HP, DEC, IBM, Silicon Graph-

ics, Symbolics, and NEXT; advanced tool for systems and software engineering, modeling, and human-computer interface design; and expert systems shells and development environments.

Contact:

James Chesney
(301) 286-9029
VLSI Systems
Sylvia Sheppard
(301) 286-5049
Human-Machine Interfaces
Computer Aided Systems Engineering
Jay Costenbader
(301) 286-5292
Planning and Scheduling
Walt Truszkowski
(301) 286-8821
Artificial Intelligence

Flight Dynamics Division

Research is conducted toward the development of algorithms and techniques to support flight dynamics mission requirements. Areas of particular interest are spacecraft orbit and attitude dynamics modeling and the development of dynamics simulators, planning of launch and maneuver parameters to tailor spacecraft trajectories for specific missions such as the *International Cometary Explorer* (ICE) mission, analysis and evaluation of advanced sensor and actuator hardware including the characterization of error sources, and development of efficient and robust algorithms for the estimation of spacecraft attitude and orbit parameters. This research depends on contributions from astrodynamics, linear and nonlinear estimation theory, system identification, linear and nonlinear dynamic system analysis, and applied mathematics.

Another significant area of research is in systems and software engineering. This research is conducted for the purpose of applying results to the mid- to large-scale software/systems development activities that also take place within the division.

Through experimentation and empirical studies in the flight dynamics software productive environment, numerous development technologies and approaches are studied. Effects of available practices are studied by quantitatively assessing their impact on cost, reliability, and general quality of newly developed flight dynamics systems. Major experiments are currently active or planned in the following disciplines:

- Ada, as a development language and overall design discipline
- Reusable software concepts and approaches
- Structured methodologies such as the "Clean Room" approach
- Software development environments
- Software maintenance tools and techniques

Research in the systems engineering disciplines includes:

- Development of advanced graphics techniques for flight dynamics problems
- Application of expert system technology to flight dynamics.

Contact: Frank McGarry
(301) 286-6846

Optics Laboratory

The Optics Branch conducts research and development programs in the optical sciences to support flight experiment development in the areas of high energy astrophysics solar and stellar astronomy, atmospheric sciences, and to a lesser extent with ocean and terrestrial sciences. Specific research and development objectives include optical property characterization of solids and thin films, diffraction grating technology, optical system design and analysis, and advanced optical fabrication and testing techniques. Modern laboratory facilities are equipped for optical property studies in the far-infrared to the extreme ultraviolet, generation of holographic diffraction grating, and optical fabrication and testing. In addition, extensive computer facilities are available to support optical design and analysis studies.

Contact: John Osantowski
(301) 286-6706

Jet Propulsion Laboratory

Program Administrators

Dr. Harry I. Ashkenas
Mail Stop 183-900
Jet Propulsion
Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-8251

Ms. Carol S. Hix
University Affairs Office
Mail Stop 183-900
Jet Propulsion
Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-3274

The primary role of the Jet Propulsion Laboratory within the NASA family is the exploration of the solar system, including planet Earth, by means of unmanned, autonomous spacecraft and instruments.

In addition, an active community of JPL scientists, technologists, and engineers is engaged in Earth atmosphere and geosciences, oceanography, planetary (including asteroid and comet) studies, and solar, interplanetary, interstellar, and astrophysical disciplines.

Opportunities for Graduate Student Researchers exist in all eight technical divisions of JPL. These technical divisions, organized by general discipline area, encompass almost the whole JPL engineering and science resources. Within each technical division is contained the planning, design, development, engineering, and implementation functions relevant to its discipline area. Fundamental to the structure of JPL is the cooperation between the research, science and advanced technology and the engineering functions of these operating divisions.

Systems Division

The Systems Division performs systems engineering and design integration for all the major projects undertaken by JPL. It also conducts specialized analyses in many disciplines to support these projects.

Contact: Christopher Carl
(818) 354-3017

Mission Design — Includes interplanetary spacecraft trajectory design, planning mission sequences to accommodate science requirements, launch vehicle trajectory analysis, studies of advanced interplanetary scientific missions, and software development to support mission design and analysis.

Spacecraft System Engineering — Supports JPL flight projects by providing design integration of the total spacecraft system, including its interfaces with the launch vehicle and with its scientific instrument payload. It also conducts studies and analyses of advanced future spacecraft designs and analyzes the performance of spacecraft in flight.

Navigation Systems — Develops the capability to determine very precisely the position and velocity of scientific spacecraft in interplanetary space through radiometric and optical techniques, designs propulsive maneuvers to place spacecraft on correct trajectories, develops complex software to solve the equations of motion, and conducts scientific studies of relativistic gravity, planetary orbital dynamics gravitational radiation and planetary mass and gravity fields using spacecraft radio tracking data.

Mission Profile and Sequencing — Develops the detailed sequences to be executed by interplanetary spacecraft, plan the commands required to carry out the sequences, and develop the software that keeps track of the command sequences and ensures the commands will safely perform the desired functions.

Mission Information Systems Engineering — Plans for the operation of interplanetary spacecraft in flight, including design of ground computers and software that process the data, design integration of the end-to-end data systems from the spacecraft instruments to the scientist receiving the data, and development of large data systems for other ground-based applications.

Systems Analysis — Performs economics, operations research, costing, and mission analyses for a broad spectrum of unmanned and manned space projects and military and civilian ground-based programs.

Tactical Information — Performs system level design integration and develops computer hardware and software for a large military data merging system. Disciplines in the division include traditional electrical, mechanical, aeronautical, and aerospace engineering, along with computer science, operations research, economics, and the physical sciences.

Earth and Space Sciences Division

The Earth and Space Sciences Division conducts a wide-ranging program of research in oceanography, the atmospheres, and solid bodies of the Earth and other planets, planetary satellites, asteroids, comets, interplanetary medium, the search for extraterrestrial intelligence (SETI), and selected solar, stellar, and interstellar phenomena. Ground-based observations from the visible through radio frequencies are conducted from a variety of facilities including the NASA/JPL Table Mountain Observatory. Active and passive remote sensing experiments covering ultraviolet through radio wavelengths are flown on aircraft, balloons, and rockets as well as Earth-orbiting and planetary spacecraft. X-ray, gamma-ray, magnetic field, and solar wind measurements are also carried out with spacecraft instruments. Extensive laboratory and theoretical research efforts and significant technology development work support these observational programs. Data analysis, interpretation, and modeling are central endeavors in all areas of activity. Summaries of the most significant current efforts are given below.

Contact: Clifford Heindl
(818) 354-4603

Oceanography — Altimetry for determining currents and tides; air-sea interactions including fluxes of mass, momentum, energy, and chemicals between ocean and atmosphere; determination of marine biomass and ocean productivity; sea ice dynamics and influence

on climate variability; global surface temperature measurements; surface driving forces and wave propagation derived from radar observations.

Contact: Donald Collins
(818) 354-3473

Earth Atmosphere — Laboratory research, field measurements and data analysis to understand the chemistry of stratospheric ozone; monitoring of long-term trends in important minor and trace constituents; extraction of meteorological parameters from satellite data including temperature profiles, humidity, clouds, winds, and pressure.

Contact: James Margitan
(818) 354-2170

Planetary Atmospheres — Observations from ground-based telescopes and analysis of spacecraft data to determine composition, structure and dynamics; long-term study of seasonal and interannual variability; global mapping; synthesis of information to determine physical processes and state of the atmospheres.

Contact: John Appleby
(818) 354-3943

Earth Geoscience — Characterization of exposed rocks, sediments and soils on the Earth's surface to understand evolution of the continents; examine state and dynamics of biological land cover for assessment of the role of biota in global processes; tectonic plate motion; volcanology; paleoclimatology.

Contact: Diane Evans
(818) 354-2418

Planetology — Observations of the surface of the inner planets, satellites and rings of the outer planets, asteroids and comets across the spectral range from ultraviolet through active and passive microwave; studies of meteorites and cosmic dust; theory and modeling relevant to the origin and evolution of the solid bodies of the solar system; development of approaches to the detection and characterization of solar systems around other stars.

Contact: Steven Baloga
(818) 354-2219

Space Physics — Mapping of the magnetic fields of the Sun and planets and their time variations; structure and dynamics of the solar wind; interactions of solar fields and particles with the magnetic fields and outer atmospheres of Earth and planets.

Contact: Marcia Neugebauer
(818) 354-2005

Astrophysics — Variability of the solar constant; sky survey of infrared sources; composition and chemistry of interstellar clouds, identification of gamma-ray sources within the galaxy and beyond; observations of supernova 1987A; studies of gravitational wave detection utilizing spacecraft.

Contact: Samuel Gulkis
(818) 354-5708

Telecommunications Science and Engineering Division

Astrophysics — Observational and theoretical research into the nature of radio emission from quasars, galaxies, and stars.

Contact: Robert Preston
(818) 354-6895

Radio Science

Gravitational Wave Studies — Algorithm development and data analysis of spacecraft tracking data for the detection of very-low-frequency gravitational waves predicted by general relativity and other theories of gravity.

Contact: John Armstrong
(818) 354-3151

Planetary Atmospheres and Interplanetary Media — Experimental and theoretical research investigations based on the use of spacecraft radio signals to probe planetary atmospheres and the interplanetary/solar plasma.

Contact: Richard Woo
(818) 354-3945

Planetary Dynamics — Determination of orbital, rotational, or atmospheric motions of planets by tracking of spacecraft or balloons associated with the planets.

Contact: Robert Preston
(818) 354-6895

Asteroid Dynamics — Study orbital evolution of main belt and planet crossing asteroids, resonances, and asteroid families.

Contact: James Williams
(818) 354-6466

Geodynamics — Experimental and theoretical investigations of global and regional phenomena using the modern space geodetic techniques of lunar laser ranging, Very Long Baseline Interferometry (VLBI) and the Global Positioning System (GPS).

Contact: Jean Dickey
(818) 354-3235

Information Theory and Coding — Theoretical research into information theory and coding with special emphasis on very noisy channels and some interest in fading and bandlimited channels.

Contact: Laif Swanson
(818) 354-2757

Optical Communication — Theoretical and experimental research involving free space laser communications systems, components, and techniques, and including such items as lasers, detectors, modulators, signal design, large telescope design, spatial and temporal acquisition and tracking, detection strategies, and channel coding.

Contact: James Lesh
(818) 354-2766

Frequency Standards Research — Experimental investigations including ultra-high resolution spectroscopy to support development of stable sources of microwave and optical frequencies.

Contact: Lute Maleki
(818) 354-3688

Planetary Radar Astronomy — Experimental and theoretical research in planetary surface, atmospheres, and rings (including geology, spin dynamics, and scattering properties of rings and cometary debris swarms) using the ground based Goldstone radar system to form images of terrestrial planets, asteroids, and comets.

Contact: Raymond Jurgens
(818) 354-4974

Radar Remote Sensing of the Earth —

Experimental and theoretical investigations in remote observation of the Earth's surface through radar scattering properties, for example, polarization and interferometry to determine the structure and motion of regions of interest.

Contact: Howard Zebker
(818) 354-8780

Electronics and Control Division

Advanced Control Systems - Development of concepts, actuators and sensors to enable high bandwidth control of flexible space structures, and to provide active shape control and active damping. Development of modeling and simulation tools, computational procedures and architectures for design and analysis of electro-mechanical control systems.

Contact: Guy K. Man
(818) 354-7142

Autonomous Systems - System architectures, sensors, actuators, for autonomous rendezvous, docking, aerobraking and landing.

Contact: George Sevaston
(818) 354-0395

Electro-optical Tracking Systems - Development and testing of electro-optical sensors and algorithms for star, limb and target-feature tracking.

Contact: Randy Bartman
(818) 354-6631

Power Research and Engineering - Development of lightweight, high-power density photovoltaic arrays; high efficiency thermal-to-electric conversion for space nuclear power; high energy batteries; power electronics and automated power systems management.

Contact: Perry Bankston
(818) 354-6793

Hypercube - Application of the Hypercube concurrent computer to computationally intensive problems in areas such as astrophysics, geophysics, image processing and data analysis.

Contact: Jean Patterson
(818) 354-8332

Flight Computers - Development of computer technology for flight application, including fault-tolerant architectures, special purpose VLSI, radiation resistance, high speed optical computing and networking.

Contact: Steve Gunter
(818) 354-0803

Microelectronic Device Research - A wide variety of research is being pursued using the new Microdevices Laboratory; Submillimeter and infrared radiation detectors, electron tunneling microscopy, quantum well structures, molecular beam epitaxy, chemical vapor deposition, E-beam lithography, transmission electron microscopy, etc.

Contact: Satish Khanna
(818) 354-4489

Autonomous Mobile Vehicle - Real-time path planning in uncertain terrains; wheeled locomotion and mobility, image processing for rover control and combined mobility and manipulation.

Contact: Brian Wilcox
(818) 354-4625

Robot Arm Control - Research in advanced modeling, adaptive control, hierarchical control software architectures, complex task simulation, etc., as they pertain to redundant dual-arm manipulation systems.

Contact: Homayoun Seraji
(818) 354-4839

Advanced Teleoperation and Man-Machine Systems - Man-machine interfaces for advanced teleoperation and supervisory automation, including the development of electro-mechanical and computing architectures.

Contact: Paul Schenker
(818) 354-2681

Data Storage Technology - Investigation of semiconductor and magnetic materials for the development of data storage technology for space, including advanced technology such as Vertical Bloch Lines (VBL).

Contact: Henry Stadler
(818) 354-3556

Mechanical and Chemical Systems Division

The Mechanical and Chemical Systems Division carries out research in a number of areas related to structures, materials, and thermal sciences. Research opportunities exist in development of dimensionally stable composite materials, polymeric materials with unique electronic and optical properties, use of active members to control vibrations and for shape control of precision structures, cryogenic cooling systems, including sorption refrigeration, adaptation of Stirling cycle coolers to space instruments, and advanced superfluid helium cryostats, electric propulsion and autonomous mobility, and sample acquisition.

Contact: Donald Rapp
(818) 354-4931

Information Systems Division

The Information Systems Division performs a variety of research and development and system implementation activities. Primarily concerned with ground-based processing, the division's R&D disciplines range from computer science through software engineering. Implementation activities include the development of the information systems orchestrating spacecraft communications and data acquisition, spacecraft and link monitoring and controlling, and distribution of telemetry data. The Deep Space Network, with tracking complexes in Canberra, Australia, Madrid, Spain, and Goldstone, California, and the Space Flight Operations Center, in Pasadena, California, form a worldwide, real-time, highly dynamic, and interactive system capable of reaching beyond the edge of the solar system. Specific research and development areas include (1) application of expert systems to spacecraft and ground data system event scheduling and failure identification, isolation, and recovery; (2) development and application of computer graphics and simulation techniques to knowledge fusion, human-machine interfaces and education; (3) investigation into effective distributed, failure-resistant information networks; (4) integration of humans into complex information systems; (5) research into the engineering processes involved in producing and maintaining

software in order to improve productivity and reliability; (6) numerical analysis including the development of large portable mathematical tool sets and the use of concurrent processors in numerically intensive problems; (7) use of large interactive and distributed data bases for oceanographic analysis; and (8) use of artificial intelligence to aid in the process of creating software.

Contact: Robert C. Tausworthe
(818) 354-2773

Institutional Computing and Mission Operations Division

The Institutional Computing and Mission Operations Division is responsible primarily for spacecraft and ground system integration and test, flight mission operations, and institutional computing. In this role, the Division provides the research, development, planning and operations necessary for spacecraft assembly, system test and integration to the launch vehicle; ground system test; mission command and monitor; and the large scale, general purpose communication and computer networks in support of the general JPL user. The Division is also responsible for microprocessor hardware and software applications; computer science education, including use of the CRAY; electronic, electrical, optical, and physical measurements; and measurement standards.

Contact: Bill Jensen
(818) 354-3146

Observational Systems Division

The Observational Systems Division is responsible for the conception, design, engineering development, and implementation of a variety of scientific instrumentation for space flight applications. A key element in the division is digital image processing research and development for space science and environmental and earth resources applications.

Contact: Kane Casani
(818) 354-4040

Imaging Systems — Design, development, and implementation of imaging and spectrographic systems for use in space science investigations. Developed imaging systems for Voyager, Galileo and Hubble Space Telescope Missions. Currently developing imaging systems for the Comet Rendezvous Asteroid Flyby/Cassini Missions, the Multi-angle Imaging Spectroradiometer for the Earth Observing Mission and the Pressure Modulator Infrared Radiometer instrument for the Mars Observer Mission. In addition to end-to-end engineering of flight instruments, the section is on the forefront in research and advanced development for solid state imaging array detectors for X-Ray, ultra violet, visible and shortwave infrared detection. These advanced scientific imaging detectors will support development of the next generation of spaceborne imaging systems.

Contact: Christopher Stevens
(818) 354-5545

Infrared and Analytical Instrument Systems — Conception, design, advanced development, and implementation of scientific instrumentation for remote sensing in the infrared and in situ analyses of chemical species using mass spectrometry and scanning electron microscopy. Missions addressed include planetary exploration, Earth remote sensing, and astrophysics.

Contact: Mark Herring
(818) 354-6817

Microwave Observational Systems — Conceive, design, implement, and calibrate science instruments in the microwave through submillimeter wavelength regions. This includes advanced research and technology development of submillimeter wave components and advanced spectrometer to support near term and future science missions. They

develop opportunities for new microwave instrument systems with the user community. They also develop theoretical models describing the interaction between microwave signals and the atmospheric and surface parameters.

Contact: Tom Fraschetti
(818) 354-6677

Image Processing Applications and Development — Develops and applies image processing techniques to the display, analysis, and interpretation of image and image-related data. Utilizing engineering and artificial intelligence to develop automated and semi-automated schemes for data interpretation. Performs research and development in image processing. Also develops and applies specialized software, hardware, and systems architectures to increase the speed of computationally intensive functions on large data sets. Provides image processing and analysis support to the flight projects, imaging teams, and the science community.

Contact: Ray Wall
(818) 354-5016

Optical Sciences and Applications — Basic and applied research in advanced optics technologies. Uses unique computational tools for optical design and system analysis to support development of various remote sensing systems for astrophysics and earth and interplanetary scientific measurements. Large mirror advanced optical materials, adaptive optics, thermal infrared optics, ultra-low scattered light optics, electro-optics, hyperspeed image correlators, and sensor systems for the Long-Baseline Michelson Stellar Interferometer are examples of study areas. Development of advanced spaceflight hardware optical systems for use in the visible, infrared, ultraviolet, and submillimeter spectral regions for science applications take place in this section.

Contact: James Breckinridge
(818) 354-6785

Lyndon B. Johnson Space Center

Program Administrator

Dr. Stanley H. Goldstein
 Director, University
 Programs
 Mail Code: AHU
 NASA Lyndon B. Johnson
 Space Center
 Houston, TX 77058
 (713) 483-4724

The Johnson Space Center is involved in a wide range of activities dealing with manned spaceflight and space exploration. Areas of research available for Graduate Student Researchers are in the Engineering and Development Directorate and the Space and Life Science Directorate. Additional information concerning the following opportunities may be obtained from the program administrator.

Engineering

Crew and Thermal Division — Responsibilities include developing technology, designing, testing and analyzing environmental and thermal control/life support (ETC/LS) systems for spacecraft and extravehicular crewmembers. Engineering expertise, test capabilities in both vacuum and thermal/vacuum environments as well as computational capabilities for design and analysis are provided for advancement of ETC/LS technologies to meet the requirements of current and future space missions.

Future space missions will require regenerative environmental control and life support to eliminate expendables which must be resupplied from the Earth, and low-cost, reliable thermal management of heat dissipated by high power space systems. Research opportunities exist in the areas of (1) physicochemical and biological regenerative life support technologies for air revitalization, water reclamation and solid-waste management, (2) two-phase fluid and high flux-density heat collection, transport and rejection technologies, (3) advanced extravehicular activity (EVA) systems including astronaut space suit, portable life support sub-system and maneuvering units, air-locks and support equipment for higher EVA safety and productivity, and (4) artificial intelligence systems for monitoring and control of ETC/LS systems.

Contact: Chin Lin
 (713) 483-9126

Tracking and Communications Division - Permanent presence in space involves construction activities, Earth and orbit transfer of people cargo, scientific and engineering experiments, tracking and communications services, and Space Shuttle, and Space Station Freedom operations. These activities will require multi-target acquisition, traffic management, target identification, rendezvous, docking, and debris detection for navigation

tracking systems with a wide range of operational characteristics supporting all functions simultaneously, and multiple access, secure multi-channel communications. Innovative expert system implementations are envisioned for the control and monitoring of these complex tracking and communication systems. Additionally, vision based systems will be required for automated tracking operations such as robotics, autonomous rendezvous and docking, autonomous landing, etc. Research opportunities exist in many communications, multi-function tracking, and vision system development areas, including efficient multi-access secure communications systems, MMIC distributed array antennas, infrared and optical/laser communications systems, voice recognition systems for control operations, digital and optical transformation and correlations. Research is also conducted on end-to-end integrated systems analytical models and simulation of all tracking and communication systems.

Contact: Sid Novosad
(713) 483-0216

GN&C Systems — Responsibilities exist for the definition, development, implementation, integration, and verification of Guidance, Navigation, and Control systems for space-flight programs assigned to the center. These systems include GN&C software algorithms, navigation sensor hardware, flight control sensor and effector hardware, and redundancy management techniques. To accomplish program responsibilities, an advanced technical base is maintained involving a number of test and laboratory facilities and computer simulations to analyze, demonstrate and test new techniques and concepts. Overall coordination, integration of GN&C software and hardware, development plans, ground and flight test plans and objectives, and associated analyses of project management functions are also provided.

Research opportunities also exist in flight dynamics, aerodynamics/aerothermodynamics, and computational fluid dynamics.

Contact: Aldo J. Bordano
(713) 483-8177

Flight Data Systems — Responsibilities exist for the research, definition, development, implementation, integration, and verification of all flight data systems for manned space-flight programs assigned to the center. These systems include on-board and ground checkout, instrumentation, displays and controls, onboard data management and flight software. To accomplish program responsibilities, an advanced technical base is maintained involving a number of test and laboratory facilities. Overall coordination, assembly, and integration of hardware/software requirements schedules, development plans, ground and flight test plans and objectives, and associated analyses of project management functions are also provided. Responsibilities also exist for the test and evaluation of integrated multi-disciplined systems. Research and development is active in the Advanced Data Systems Laboratory for advanced flight displays, controls, instrumentation and data management systems.

Contact: Robert Musgrove
(713) 483-8356
Saverio Gaudiano
(713) 483-8318

Propulsion — Major propulsion activities include failure resolutions and hardware improvement of the Space Shuttle propulsion system, hardware development for Space Station propulsion and fluid distribution systems, conceptual development of advanced propulsion to support future space exploration, and general technology development as required to resolve existing and predicted propulsion and fluid system problem areas. Scope of work involves ground test of hardware, conceptual design of systems, detail design of components and analysis of systems, rocket engines, and fluid components. Specific areas of interest

are analytical modeling of fluid behavior under low gravity conditions (heat transfer, thermodynamics, acquisition, cryogenic conditioning, etc.), rocket engine combustion modeling and stability analysis, dynamic fluid system analytical modeling, and development of fluid and propulsion system on-orbit health monitoring techniques.

Electrochemical energy conversion systems are studied with emphasis on fuel cells and water electrolysis systems. Opportunities are also present for research on nickel-hydrogen and lithium battery systems. Significant advances in photovoltaic and solar dynamic power system technologies are required for successful utilization of solar energy for electrical power generation. New power management and distribution schemes must be conceived and validated. High temperature thermal energy storage technology must be advanced.

Contact: Cecil Gibson
(713) 483-9041
Power
Ralph Taeuber
(713) 483-9002
Propulsion

Structures and Mechanics - Capabilities exist in the general area of materials science including fracture mechanics, electron and optical microscopy, nondestructive examination, and failure analysis. Current research activities are mostly related to theoretical and experimental work in fracture mechanics and nondestructive examination. Numerical solutions are derived for stress-intensity factors; methods are being improved for fatigue crack growth analyses; and experimental work is being conducted to better understand crack growth behavior. For nondestructive examination, methods are being studied to improve the reliability of detecting crack-like defects, particularly embedded cracks, tight cracks, and smaller cracks.

Contact: Royce Forman
(713) 483-8926

Systems Engineering - Simulation support is provided to the JSC space program for engineering design, development, analysis, validation, and verification. Integrated simulated systems include Shuttle, Space Station, Manned Maneuvering Unit, Orbital Transfer Vehicle, robotics and manipulators, payloads, artificial intelligence, and expert systems with subsystems required for particular tasks. Research opportunities exist in the areas of simulation and modeling computer systems.

Research and engineering efforts are directed toward the definition, analysis, and characterization of a wide variety of space-related activities, including advanced space transportation systems, evolution of the Space Station, future lunar efforts, and planetary missions. Research opportunities exist in advanced mission characterization, concept development, systems analysis, system design and performance.

Contact: Y.M. Kuo
(713) 483-1550
Simulations
Richard L. Barton
(713) 483-4650
Advanced Programs

Automation and Robotics - The Intelligent Systems (IS) Branch conducts research in Artificial Intelligence (AI) and Robotics for application to spaceflight and supporting ground operations. The primary activity in AI is in development of expert systems for monitoring, diagnosis, planning and control with emphasis on developing deep, model based, expert systems which can be used in building highly autonomous space flight systems. The primary activity in robotics is in the development of techniques for extracting and integrating sensory information, and techniques for planning and learning to produce mobile robotic systems capable of highly autonomous retrieval, assembly, service,

repair, and inspection activities. However, research opportunities exist in most all categories of AI. Preference will be given to research activities which can be conducted in a hardware/software environment similar to the one used by the IS Branch so that research results can be shared. Currently the IS Branch uses the Symbolics 3600 series Lisp Machines, work stations with the KBVision computer vision system, and VAX 11/780 running ULTRIX. The branch is on Internet and the Computer Science Network.

Activities in the research and development of telerobotics and autonomous robotic systems include the development of hardware and software upgrades to the Shuttle Remote Manipulator System; the integration of the Space Station Mobile Service Center and the Flight Telerobot Servicer into both the Space Shuttle for the assembly of Space Station and into the Space Station itself for long term maintenance; and the development of advanced robotic systems and components to provide adaptive robots for long term autonomous missions in space and lunar and planetary surfaces.

In support of space operations requiring robotic applications, the Robotic Applications Labs are pursuing emerging technologies such as advanced control schemes (i.e., force/torque feedback and adaptive control), multi-arm control (for both kinematically sufficient and redundant systems), external sensing, collision detection and avoidance, and on-line path planning. Simulations will be developed and verified, and hardware components will be introduced to validate algorithms since implementation eventually involves hardware.

Functional capabilities are being developed for an intelligent robot equipped with dexterous hands/arms to fulfill the future need

for autonomous, dexterous robots. Current research efforts include the development of intelligent control systems for arms and hands; coordinated control of dual hand/arm systems; proximity/tactile sensor systems for adaptive grasping and manipulation; and neural networks.

Research in the area of computer graphics is being actively pursued in support of robotic real-time man-in-the-loop simulation development as well as for video documentation of robotic scenarios. This includes research and development of algorithms for lighting computations such as radiosity and ray tracing; developing efficient graphics front ends to simulations which must run in real time; animation; and geometric modeling.

Contact: Kathleen J. Healey
(713) 483-4776
Artificial Intelligence
Charles R. Price
(713) 483-1523
Telerobotics
Charles J. Gott
(713) 483-8107
Robotic Applications

Information Systems

Artificial Intelligence — Responsible for developing and evaluating software technology in support of NASA institutional and mission operations. A number of ongoing research projects offer the potential for major contributions to the integration of artificial intelligence technology with robotics, image and speech analysis, training, software development, flight design and control, intelligent data base technology, machine learning, and intelligent man-machine interfaces.

Current efforts include research into the development of general-purpose intelligent training systems; expert assistants for flight controllers; neural networks for robotics simulation, machine learning, and image/speech recognition (as well as speech generation); implementation of expert systems on parallel/distributed systems; verification/validation techniques for expert systems; the application of artificial intelligence to computer aided software engineering (CASE); the application of fuzzy logic to control; the development of genetic algorithms for optimization; the development of planning and scheduling technology; and the development of knowledge capture technology.

Contact: Robert Savely
(713) 483-8105

Safety, Reliability, and Quality Assurance

Risk Management — Complex space programs with long lead times and high costs demand advanced risk management techniques which dynamically integrate the functions of hazard identification, the potential for occurrence, and the level of program impact. Opportunities exist for research in the development and implementation of both quantitative and qualitative techniques to identify the parameters of a comprehensive risk management program for complex space systems and facilities which provide for accurate assessment of the human interfaces in each area. Approaches to be considered in such a comprehensive program include, but are not limited to, statistical modeling of failures and their effects; probabilistic risk assessment; fault tree, event tree, or decision tree analysis; and the dynamic integration of element hazards arising from both ground and mission phases. The objective of the research is to develop an approach which successfully melds hazard control and fault tolerance

criteria, risk management techniques, systems performance, and human performance in a dynamic continuum of mission activities which will support the achievement of a corresponding level of dynamic risk measurement and appraisal which lead to sound risk management decisions.

Contact: Richard Holzapfel
(713) 483-4290

Space and Life Sciences

Biomedical Sciences — The absence of hydrostatic forces, which results in body fluid shifts, and the absence of deformation forces on normally load-bearing tissues, are postulated to cause the principal disturbances found during and after space flight in the fluid and electrolyte, cardiovascular, erythropoietic, musculo-skeletal, immunological, and metabolic systems. These alterations result in a multitude of physiological imbalances such as a reduced body fluid volume with concomitant losses of electrolytes, loss of body calcium stores, skeletal muscle atrophy, and a negative energy balance after prolonged space flight. The purpose of the present program is to study and define, at the cellular, biochemical, and endocrine levels, key elements underlying the integrated physiological responses to space flight allow the definition and assessment of crew health status and which reveal areas of countermeasure development.

The JSC Biochemistry Research laboratories perform studies using simulated models of the space environments such as head-down bedrest or water immersion in an attempt to reproduce the observed changes and to assess them at a biochemical and cellular level of function. The cellular level of understanding in key changes such as fluid regulation and metabolism is also examined in vitro using cell culture techniques. Collectively these studies will advance our knowledge of the physiological changes relevant to fluid and electrolyte alterations, erythropoietic homeostasis, calcium and mineral biochemistry and metabolic balance disturbances experienced in microgravity.

In collaboration with various groups, studies are conducted into the pituitary and adrenal responses to stress, hormonal control of calcium and protein metabolism, sodium homeostasis, and renin-aldosterone responsiveness. The laboratory is also engaged in performing biochemical analyses in support of manned space missions. Plasma and urine analyses are used as indicators of crew physiological status before, during and after flight. Flow cytometry and digital image analysis are used to quantitate immunological alterations resulting from space flight. Previous observations suggest a depressed immune response that may be a significant factor in long-term space flight. More detailed studies of immune function will be necessary to understand the effects of microgravity/stress on the immune system. Prolonged space missions and the need to monitor and correct biochemical changes in flight necessitate the development and refinement of techniques for electrolyte and hormone assays that are suitable for use in zero-gravity environments.

The laboratory is actively pursuing the following: (1) development of analytical procedures for routine determination of hormone-binding proteins; (2) refinement of existing techniques of radioimmunoassays for antidiuretic hormone, atrial natriuretic factor (ANF), and parathormone; (3) development of analytical methods for hormones and vasoactive agents implicated in renal physiology; (4) development and field testing of new concepts of automated biochemical analysis; and (5) testing of analytical procedures in simulated and actual spaceflight for simplicity of use, accuracy, reproducibility and non-invasiveness.

Contact: Nitza Cintron
(713) 483-7165

Biological Processing in Weightlessness

Microgravity can be used to enhance the separation or synthesis of medically important biologicals from suspension-cell cultures. In weightlessness, liquids and gases exhibit novel behavior, convective mixing is virtually absent, and immiscible mixtures can remain stable for prolonged periods. Various gravity-dependent processes have been examined to determine whether, in the absence of gravity, significant improvements in process technology can be achieved. Shuttle flight experiments demonstrate that both free-flow and static electrophoretic systems can achieve better separations of certain cells in weightlessness than is possible on Earth. Researchers are also examining different physical phenomena and the resulting effects on fluid mechanics in the weightless environment of space. Theoretical and experimental work will assess the significance of these physical changes to biological systems. The major thrust of this program is to explore improvement in biological separations and cell-culturing techniques under microgravity conditions. Continuous flow electrophoresis and recirculating isoelectric focusing of cells and proteins are being compared, or new candidates for flight experiments are being evaluated. The bioprocessing laboratory is developing a prototype microcarrier bioreactor for conducting cell-culture experiments in microgravity and provides biological laboratory support for electrophoresis of kidney, pituitary of flow cytometry, cell sorting, hybridoma production of specific antibodies, enzyme-linked immunosorbent assays, and cell growth on microcarrier beads. Research associates also can collaborate with scientists at the Bioprocessing Research Center at the University of Texas Health Science Center, which is under contract to JSC.

Contact: Clarence Sams
(713) 483-7160

Pharmacokinetics Research — Pharmacokinetics of drugs administered to crew members during flight are subject to variability as a result of exposure to weightlessness. Identification and evaluation of these changes in the pharmacokinetic behavior of therapeutic agents is essential for designing and developing effective treatment regimens for space flight-induced pathophysiologic conditions like space motion sickness.

The biochemistry research laboratories conduct research in the areas of clinical pharmacokinetics and biopharmaceutics. The special areas of our interest are development of simple and noninvasive drug monitoring methods that are flight suitable; evaluation of pharmacokinetic changes of drugs during antiorthostatic bedrest; identification of physiologic changes that influence drug disposition, such as a hepatic and renal function, gastro-intestinal physiology, and changes in protein binding of drugs, using simulation models. Our group is also involved in a number of inflight pharmacokinetics research projects. Research in the area of physiologic-pharmacokinetic model development is also actively pursued.

Clinical facilities and staff to conduct human research are provided by collaborating institutions and inhouse contractor personnel. Fully equipped, inhouse analytical laboratories are available to support pharmacokinetics research. An inhouse computer facility with a wide range of statistical software packages is also available for pharmacokinetic data analysis and modeling.

Contact: Nitza Cintron
(713) 483-7165

Lunar Base Technology

Planetary Materials Analysis — Laboratory analyses of lunar rocks, terrestrial rocks, meteorites, and cosmic dust particles are conducted to unravel the early geochemical history of solid matter in the solar system and the geologic evolution of planets and rocky protoplanetary objects, including comets.

Cometary studies by remotely sensed data of Earth and other planetary bodies are also used for these same objectives. Determinative mineralogy employs electron microscopy and microprobe analysis, as well as X-ray and electron diffraction analyses. Trace element concentrations are determined by instrumental neutron activation analysis. Isotopic data is gathered by solid source and gas source mass spectroscopy. Light elements are analyzed by chromatography and quadropole mass spectroscopy. Interactions of water and planetary materials are studied by low-temperature differential scanning calorimetry and by computation of mineral-fluid reaction relationships.

Contact: William Phinney
(713) 483-5310

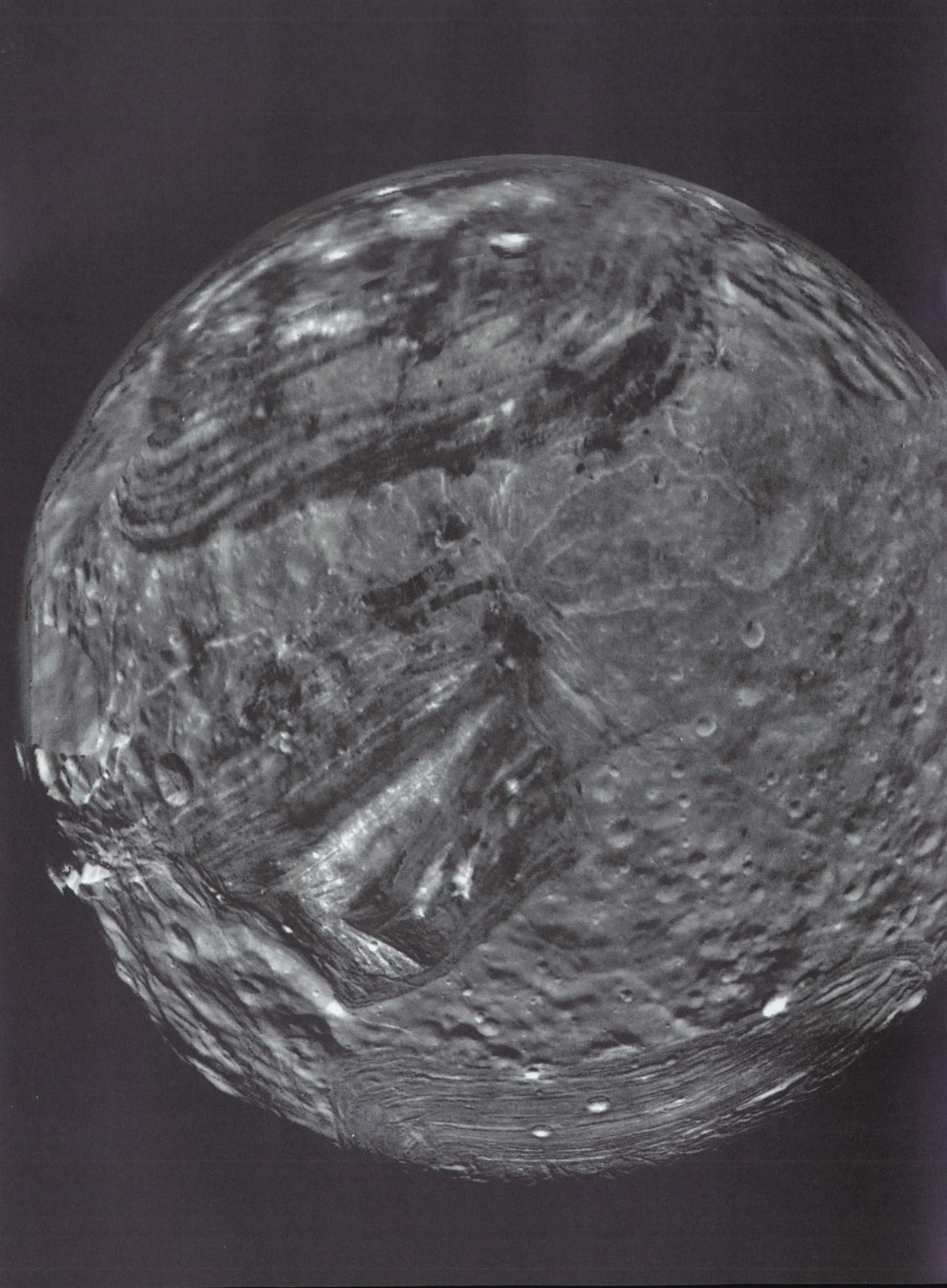
Space Science

Orbital Debris — Theoretical and experimental research in fields related to the orbital debris program. Includes research on the orbital mechanics of space debris in both low Earth orbit and geosynchronous orbit, measurement of orbital debris by optical, infrared, and radar techniques, and laboratory and experimental research on hypervelocity impact phenomena.

Contact: Donald Kessler
(713) 483-5313

Space Radiation — Theoretical and experimental research in space radiation, with emphasis on aspects related to radiation biology. Includes applied research on radiation dosimetry and basis research on modeling and measurement of the radiation environment in low Earth orbit.

Contact: Gautam Badhwar
(713) 483-5065



John F. Kennedy Space Center

Program Administrator

Bill J. Martin, Manager
 University Liaison
 Mail Code PT-PAS
 John F. Kennedy Space
 Center
 National Aeronautics and
 Space Administration
 Kennedy Space Center,
 FL 32899
 (407) 867-2512

The John F. Kennedy Space Center, located near Cape Canaveral, Florida, is NASA's primary launch site. The center handles the preparation, integration, checkout and launch of space vehicles and their payloads. Areas of research available for Graduate Student Researchers are in the engineering and operations research and the Earth sciences. Additional information concerning the following opportunities may be obtained from the program administrator.

Engineering

Advanced Programs — Research and engineering efforts related to Launch and Landing activities for manned and unmanned space launch vehicles need technology development capabilities. These include launch facilities design using materials and components which can withstand the unique environmental conditions at the Atlantic beach on the eastern shore of Florida, coupled with the harsh components of the plume created by liquid and solid fueled rockets. Materials design, structural design, ground support equipment design and development and systems engineering for integrating these components are fertile fields for Graduate Student involvement. Laboratories and equipment for these fields of study are available at the Kennedy Space Center. The NASA engineers and managers to lead and provide guidance are supported by local colleges and universities. Opportunities also exist for computer systems programming, network development and management, development of software, and artificial intelligence to support technology for the launch environment.

Contact: Tom Davis, Manager
 (407) 867-7705
 Advanced Systems and
 Technology Office

Operations Research

Advanced Programs — KSC's responsibility in the Space Exploration Initiative (e.g., Lunar Mars) include several functions which are suited to Operations Research project development. Math models are the logical method to anticipate the jobs to do and the way to do them in the early design phase of integrated operations and integrated logistics. These functions are within the Mission Analysis/System Engineering (MASE) responsibilities of Level II being supported by KSC along with seven other NASA centers. Launch site opera-

tions, facility assessments (including sizing, impacts) and determining the requirements based upon the total launch vehicle and cargo processing could also be enhanced by math models. Performing the tasks associated with launch operations on the surface of the Moon and Mars would benefit from the talents of Operations Research Engineers.

Contact: William Goldsy, Manager
(407) 867-3644
SEI Staff PT

Earth Sciences

Advanced Programs — Efforts are underway at KSC to describe lightning ground flashes.

Triggering of flashes is performed for observation. Simulation with an electrostatic generator is performed, and observations are made with unique sensor systems including an electric field mill network, a ground flash locating system, and a VHF pulse observing system. A unique dense network of wind, temperature, and relative humidity sensors is in use along with an array of acoustic sounders and a verticle wind profiler. An airborne electric field mill project is gathering data in the vicinity of electrified clouds at altitude.

Mesoscale numerical modeling and prediction efforts are underway in connection with the need for realtime predictions of mesoscale thunderstorm formation. A dense network of rain gauges is being deployed to establish ground truth for satellite rain sensor calibration. Long-range plans include the study of lightning initiation and lightning ground contact effects, description of electrified cloud development, and mesoscale numerical prediction of cloud development, distribution, and transport and diffusion of hazardous and toxic materials. Contact:

James Nicholson
(407) 867-2780
Advanced Systems and Design
Office, PS-AST
Launa Maier
(407) 867-4738
AF RCC Tech Transition
Unit, TE-CID-3

CELSS Research Opportunities

Areas of research in the CELSS Breadboard Project include crop growth and production, chemical allelopathy, microbiological pathology, biomass conversion, and system control and automation. Crop production research is conducted in NASA's Biomass Production Chamber (BPC) to determine plant growth (yield), gas exchange (CO_2 , O_2 , and H_2O), and nutrient uptake on a community level. Opportunities exist to conduct short-term environmental response tests for community gas exchange and nutrient uptake. Opportunities also exist to conduct research on the carbon exchange rates and carbohydrate metabolism of higher plants in response to gravity. Research that will produce an understanding of trace gaseous and microbiological contaminants in a CELSS system, their source, dose response effects on plants, and control methodologies is encouraged. Biomass conversion research opportunities are available in several areas including: extraction of water soluble compounds from crop residue, enzymatic hydrolysis of crop residue cellulose, production of edible mycoprotein from glucose, conversion of organic particulates and soluble residues from all other reactors into microbial biomass. Research opportunities exist in applications of robotic techniques for planting, culturing, and harvesting of candidate crops in a closed growth chamber and to define control responses in the system upon which to base optimization algorithms and the development of process sensors. Contact:

William M. Knott
MD-RES-L
(407) 853-5142

Langley Research Center

Program Administrator

Dr. Samuel E. Massenberg
 University Affairs Officer
 Mail Stop 105A
 NASA Langley Research
 Center
 Hampton, VA 23665-5225
 (804) 864-4000

The research program of the Langley Research Center is very broad and includes activities in aeronautics, space, space science, atmospheric science, and applications. The following topics identify the current disciplines relevant to the Langley program. Specific research activities associated with each discipline are also included.

Aeronautics Directorate

The goal of the aeronautics research program is to establish a solid foundation of aeronautical technology and provide a wellspring of ideas for advanced aeronautical concepts. This program includes the following disciplines and specific research activities.

Fluid Physics — Subsonic aerodynamics, transonic aerodynamics, high-speed aerodynamics, computational fluid dynamics, turbulent drag and noise reduction, airfoil aerodynamics, advanced test techniques, full scale Reynolds number test technology, and flight research measurement techniques. Contact:

Edgar G. Waggoner
 (804) 864-5055

Subsonic Aerodynamics

Lawrence E. Putnam
 (804) 864-2847

Transonic Aerodynamics

David S. Miller
 (804) 864-5568

High-Speed Aerodynamics

Ajay Kumar
 (804) 864-2285

Computational Fluid Dynamics

Dennis M. Bushnell
 (804) 864-5705

Turbulent Drag Reduction

Robert J. McGee
 (804) 864-1005

Airfoil Aerodynamics

Robert A. Kilgore
 (804) 864-5020

Advanced Test Techniques

Lawrence E. Putnam
 (804) 864-2847

Full-Scale Reynolds No. Test Tech.

Bruce J. Holmes
 (804) 864-6048

Flight Research Measurement
 Techniques

Propulsion — Propulsion integration, hypersonic propulsion research, advanced turbo-props (noise reduction). Contact:

Bobby L. Berrier
 (804) 864-3016

Propulsion Integration

Griffin Y. Anderson
(804) 864-6236
Hypersonic Propulsion Research
William P. Henderson
(804) 864-3520
Advanced Turboprops
(Noise Reduction)

General Aviation — Aerodynamics and handling qualities, drag reduction, separated flow control (stall/spin). Contact:

Joseph L. Johnson
(804) 864-1137
Aerodynamics and Handling
Qualities
H. Paul Stough
(804) 864-3860
Stall/Spin
Bruce J. Holmes
(804) 864-6048
Drag Reduction

High-Speed Aircraft — Flight dynamics and rocket-borne, small-scale flight research.

Contact:
Joseph L. Johnson
(804) 864-1137
Flight Dynamics

Advanced Aircraft Systems — Aerodynamics, structures, acoustics of advanced flight systems. Contact:

Wallace C. Sawyer
(804) 864-6515
Advanced Military A/C and Missiles
Samuel M. Dollyhigh
(804) 864-6503
Advanced Aircraft Systems

Transport Aircraft — Aviation meteorology research-heavy rain effects, lightning, severe storms, wake vortex minimization, laminar-flow control, high Reynolds number research, configuration aerodynamics.

Contact:
Dana Dunham
(804) 864-5061
Heavy Rain Effects
Bruce D. Fisher
(804) 864-3862
Lightning, Severe Storms
George C. Green
(804) 864-5545
Wake Vortex Minimization

Richard D. Wagner
(804) 864-1903
Laminar-Flow Control
Lawrence Putnam
(804) 864-2847
High Reynolds No. Research and
Configuration Aerodynamics

Flight Systems Directorate

The goal of the Flight Systems Research Program is to provide, through basic and applied multidiscipline research activities, advanced technology needed to develop and implement future aerospace flight systems. Research activities include the following disciplines and specific research activities.

Controls and Guidance — Fault-tolerant systems, theoretical dynamics and control, crew station technology, and applied control concepts. Contact:

Charles Meissner
(804) 864-6218
Fault-Tolerant Systems
Jarrell Elliott
(804) 864-4001
Theoretical Dynamics and Control
Applied Control Concepts
Jack Hatfield
(804) 864-2012
Crew Station Technology

Human Factors — Flight management technology, advanced crew interface/intelligent cockpit aids research, and pilot workload/performance research. Contact:

Sam Morello
(804) 864-6664
Flight Management Technology
Advanced Crew Interface Research
Kathy Abbott
(804) 864-2018
Intelligent Cockpit Aids Research
Randall Harris
(804) 864-6641
Pilot Workload/Performance
Research

High-Speed Aircraft — Aspects of navigation, guidance, and control relative to high-speed aircraft. Contact:

Jarrell Elliott
(804) 864-4001
Flight Dynamics and Control

Transport Aircraft — Advanced ATC/Aircraft interaction, airborne detection of wind shear research, advanced controls, guidance, and flight management research. Contact:

George G. Steinmetz
(804) 864-2042

Advanced ATC/Aircraft Interaction
Roland Bowles
(804) 864-2035

Airborne Detection of Wind Shear
Research

George G. Steinmetz
(804) 864-2042

Advanced Controls, Guidance, and
Flight Management Research

Computer Science — Concurrent processing, highly reliable computing, information and data base management, graphics, and image processing.

Contact: Wayne Bryant
(804) 864-1092

Space Controls and Guidance — System identification and adaptive control of large flexible space structures, teleoperator/robotics system technology, and robust/failure-accommodating control design methodology for advanced spacecraft. Contact:

Claude Keckler
(804) 864-1716

System Identification/Adaptive
Control of Large Flexible Space
Structures

Jack E. Pennington
(804) 864-6677

Teleoperator/Robotics System
Technology

Claude Keckler
(804) 864-1716

Robust/Failure Accommodating
Control Design Methodology for
Advanced Spacecraft

Materials and Structures —

Contact:

Jack E. Pennington
(804) 864-6677

Automated Construction of Large
Space Structures

Electromagnetics, Antennas, and Microwave Systems — Electromagnetic analysis methods, spacecraft, and aircraft antenna technology, far-field and near-field antenna measurements, compact range technology, and microwave remote sensing technology for aircraft and spacecraft applications.

Contact: Thomas G. Campbell
(804) 864-1772

Electronics and Information System — Laser sensing technology, optical data processing, solid-state memory technology, and very high-speed information processing.

Contact: Harry Benz
(804) 864-1493

Advanced Control/Display Technology —

Contact: Jack J. Hatfield
(804) 864-2012

Optical Data Storage —

Contact: Thomas A. Shull
(804) 865-1874

Transportation Systems — Studies leading to algorithms for on-board, real-time guidance, navigation, and control of space transportation systems through launch, aeromaneuvering, and entry; robust and adaptive guidance schemes that allow for unknown and changing atmospheric conditions; simplified and autonomous mission planning.

Contact: Douglas A. Price
(804) 864-6605

Spacecraft Systems Technology —

Contact:

Harry F. Benz
(804) 864-1493

Semiconductor Material Growth in
Low-G Environment

Structures Directorate

The goals of the Structures Directorate cover a wide range of space and aeronautical disciplines. This program includes the following activities.

Structures (Space) — Materials and structures-materials for advanced space structures, thermal protection systems for space transportation systems, space structural design methods, space vehicle dynamics, high-temperature space structures, fatigue and fracture of metal and composites, composites for advanced space transportation systems.

Contact:

- Brantley R. Hanks
(804) 864-4325
Spacecraft Structural Dynamics,
Advanced Flexible Space
Structures, Control of Large
Flexible Structures
- James H. Starnes
(804) 864-2902
Composite Structures for Advanced
Space Transportation Systems,
Rotorcraft Structures
- Martin M. Mikulas
(804) 864-3102
Concepts for Advanced Space Structures
Construction of Large Space
Structures, Robotic Construction
of Large Space Structures
- Donald R. Rummmler
(804) 865-5182
Thermal Protection Systems for
Space Transportation Systems,
High-Temperature Space
Structures
- Jaroslav Sobieski
(804) 864-2799
Integrated Multidisciplinary
Analysis Capability for Large Space
Structures
- Terry L. St. Clair
(804) 864-4273
High-Performance Polymer
Concepts, Tough Composite Matrices,
Composites Processing and Adhesive
Bonding
- Charles E. Harris
(804) 864-3449
Fatigue and Fracture of Metals
and Composites

- Howard G. Maahs
(804) 864-3084
Composite Materials and Coatings,
Concepts for Applications in Space
Structures
- Mark J. Shuart
(804) 864-3170
Composite Structures for Advanced
Space Transportation Systems
- W. Barry Lisagor
(804) 864-3140
Processing and Joining Methods for
Light Weight, Lower Cost Aerospace
Structures
- Jerrold M. Housner
(804) 864-4325
Computational Structural Mechanics
- Charles J. Camarda
(804) 864-5436
Thermal Protection Systems for
Space Transportation Systems;
High-Temperature Space Structures
- Structures (Aero)** — Materials and structures-structural, composites and adhesives, advanced aircraft structures, loads, aeroelasticity and structural dynamics, aeronautical structural design methods, high-temperature aeronautical structures, structural material alloys, fatigue and fracture of metals and composites. Contact:
- James H. Starnes
(804) 864-2902
Advanced Composite Structures,
Computational Structural
Mechanics
- John A. Tanner
(804) 864-1305
Aircraft Safety and Crash
Survivability
- Allan R. Wieting
(804) 864-1359
Integrated Fluid-Thermal
Structural Analysis Techniques,
Aerothermal Loads Experimentation
- Rodney H. Ricketts
(804) 864-1207
Aircraft Aeroelasticity, Rotorcraft
Aeroelasticity, Rotorcraft
Structured Dynamics
- Jaroslav Sobieski
(804) 864-2799
Multidisciplinary Synthesis Methods
for Aerospace Vehicles

Charles E. Harris
(804) 864-3449
Fatigue and Fracture of Metals
and Composites

Howard G. Maahs
(804) 864-3084
High Temperature-Structural and
Thermal Protection Materials,
Advanced Composite Materials for
Rotorcraft and Aircraft Structures,
Thermal Protection Materials

W. Barry Lisagor
(804) 864-3140
Advanced Light Alloy and Metal
Matrix Composites, High-
Temperature Thin Gage Metal and
Metal Matrix Composites

Clemans A. Powell
(804) 864-3575
Interior Noise Control, Acoustic
Response and Sonic Fatigue

Mark J. Stuart
(804) 864-3170
Advanced Composite Structures;
Rotorcraft Structures

Jerrold M. Housner
(804) 864-4325
Computational Structural Mechanics

Charles J. Camarda
(804) 864-5436
Aero-Space Plane Propulsion and
Airframe Structural Concepts;
Thermal Structural Analysis
Techniques

Aeroacoustics — Supersonic/hyper-sonic
Dynamic Loads, High-speed Rotorcraft Noise,
Advanced Turbo-prop, Computational
Methods.

Contact:

John S. Preisser
(804) 864-3618

David Chestnutt
(804) 864-5263
Helicopter Acoustics, Propeller
Noise, Laminar Flow Acoustics,
Noise Propagation

James C. Yu
(804) 864-3640
Low-Speed Aircraft, Rotorcraft
Structural Dynamics, Material
Applications, Aerodynamics,
Aeroacoustics, and Unsteady
Aerodynamics

Electronics Directorate

The mission of the Electronics Directorate is to pioneer and provide technology, systems, and services in the areas of instrumentation, scientific computing, and simulation to sustain Langley's continued research preeminence, and to manage the Center's major aerospace flight research projects. The following items represent active research disciplines within the directorate purview.

Advanced Sensor Systems - Solid-state laser technology, and semiconductor detector technology. Contact:

Norman Barnes
(804) 864-1630
Solid-State Laser Development

William E. Miller
(804) 864-1720
Semiconductor Detector Technology

Measurement Science and Instrument Technology - Far infrared technology, electromechanical sensors, digital data systems, nonintrusive optical/laser measurements, optical/laser spectroscopy, mass spectrometry/gas chromatography, thermal measurements, structural dynamics/acoustics measurements, optical interferometry/photogrammetry techniques, and electronics applications.

Contact:

Ira G. Nolt
(804) 864-1623
Far Infrared Sensor Technology

Stewart L. Ocheltree
(804) 864-4755
Nonintrusive Measurements

Thomas A. Shull
(804) 864-1874
Advanced Electronics Systems

Harlan K. Holmes
(804) 864-4650
Electromechanical Sensors and
Structural Dynamics/Acoustics
Measurements

Robert L. Krieger, Jr.
(804) 864-4654
Digital Data Acquisition

Reginald J. Exton
(804) 864-4605
Optical/Laser Spectroscopy

Billy T. Upchurch
(804) 864-4750
Mass Spectrometry/Gas
Chromatography

Kamran Daryabeigi
 (804) 864-4745
 Thermal Measurements
 John C. Hoppe
 (804) 864-4618
 Optical Interferometry
 Photography

Materials Characterization

Technology — Ultrasonic propagation and scattering in composites, ultrasonic arrays, signal processing, image analysis, thermal wave and diffusion analysis, nonlinear acoustics, electron microscopy, microstructural physics, elastic behavior, X-ray tomography, fiber optic sensors, and electronics reliability.
 Contact:

Eric I. Madaras
 (804) 864-4993
 Ultrasonic Propagation and
 Scattering in Composites
 Patrick H. Johnston
 (804) 864-4966
 Ultrasonic Arrays, Signal
 Processing, and Image Analysis
 William P. Winfree
 (804) 864-4963
 Thermal Wave and Diffusion
 Analysis
 John H. Cantrell
 (804) 864-4989
 Nonlinear Acoustics, Elastic
 Behavior, Electron Microscopy and
 Microstructural Physics
 Min Namkung
 (804) 864-4962
 X-Ray Tomography for Stressed
 Solids
 Robert S. Rogowski
 (804) 864-4990
 Fiber Optic Sensors for Structural
 Dynamics
 Joseph S. Heyman
 (804) 864-4970
 Electronics Reliability Sciences

Advanced Computational Capability -
 Piloted simulation, computer-generated and
 enhanced graphics, image processing, grid
 generation, and numerical techniques.
 Contact:

Billy R. Ashworth
 (804) 864-6449
 Piloted Simulation
 John E. Hogge
 (804) 864-5774
 Grid Generation and Numerical
 Techniques

Space Directorate

The goal of the space and atmospheric science research and technology base is to establish and maintain a solid foundation of technology embracing all of the disciplines associated with space and atmospheric science and to provide a wellspring of ideas for advanced concepts. This program includes the following disciplines and specific research activities.

Entry Fluid Physics — Computational fluid dynamics, spacecraft aerothermodynamics and configuration technology, planetary mission support technology, aerodynamic/aerothermodynamic flight data analysis, detailed aerothermal loads. Contact:

Kenneth Sutton
 (804) 864-4406

Power and Propulsion — Laser power generation, transmission, and photovoltaic conversion in space. Contact:

Edmund J. Conway
 (804) 864-1435

Transportation Systems — Future space vehicle concept development, operations, research, computer-aided design. Contact:

Delma C. Freeman
 (804) 864-4502

Space Systems Technology — Spacecraft concept development studies for Global Change science missions; large Earth-orbiting spacecraft and platform systems studies; spacecraft subsystem analyses, performance and technology assessments;

lunar and Mars mission studies; astronaut space radiation dose and shielding analyses; mission design; computer-aided design and simulations. Contact:

L. Bernard Garrett
(804) 864-4425

Aerodynamic/Aerothermodynamic Experiments — Experimental assessment/enhancement of hypersonic aerodynamic, aerothermodynamic and fluid dynamic characteristics of future Earth and planetary aerospace vehicle concepts. Contact:

Charles G. Miller
(804) 864-5221

Space Technology Experiments — Aeroassist flight experiments, Shuttle entry air data system, Shuttle infrared leeside temperature sensing, Shuttle upper atmosphere mass spectrometer. Contact:

Kenneth Sutton
(804) 864-4406

Climate Research Program — Theoretical, laboratory, and field investigations of the chemical and radiative properties of natural volcanic and man-made aerosols and assessment of their impact on regional and global climate, remote and in situ observations of cloud properties and radiation balance components and theoretical studies of the role played by clouds in the Earth radiation balance. Contact:

John T. Suttles
(804) 864-5685

Tropospheric Air Quality Research Program — Assess and predict human impact on the troposphere on the regional-to-global scale, define chemical and physical processes governing the global geochemical cycles by performance of empirical and analytical modeling studies, laboratory measurements, technology developments, and field measurements, exploit unique and critical roles that space observations can provide. Contact:

James M. Hoell, Jr.
(804) 864-5826

Upper Atmospheric Research Program — Expand the scientific understanding of the Earth's stratosphere and the ability to assess potential threats to the upper atmosphere. Includes development of empirical and

theoretical models, formulation of new instruments and techniques, performing laboratory and field measurements, and performing data analysis and interpretation studies. Contact:

Robert K. Seals, Jr.
(804) 864-2696

Nimbus 7/LIMS and SAM II Data Processing, Analysis and Interpretation Studies — Stratospheric constituents and aerosols successfully measure with the Nimbus 7 satellite instruments. Contact:

John G. Wells, Jr.
(804) 864-1859
LIMS
Leonard R. McMaster
(804) 864-2669
SAM II

Measurements of Air Pollution From Satellites (MAPS) — An instrument developed to provide global measurements of tropospheric carbon monoxide on aircraft, Shuttle STS-2, STS-41G, and subsequent Shuttle flights. Contact:

Henry G. Reichle, Jr.
(804) 864-5383

Stratospheric Aerosol and Gas Experiment (SAGE) — Analysis and interpretation of atmospheric aerosols, ozone, nitrogen dioxide and water vapor measured from SAGE I (1979-1981) and SAGE II (1984-present) satellite instruments. Contact:

Leonard R. McMaster
(804) 864-2669

Earth Radiation Budget Experiment (ERBE) Experiment for flight on one or more satellites to provide measurements of the Earth's radiation budget, measurement interpretation to provide basis for assessing climate impact of human activities and natural phenomena as well as a better understanding of atmospheric and oceanic circulation. Contact:

Bruce Barkstrom
(804) 864-5676
Earth Radiation Budget
Experiment

John G. Wells, Jr.
(804) 864-1859
Halogen Occultation Experiment

Configuration Definition for the Evolution of Space Station Freedom — Study of the required augmentations to Space Station Freedom to accommodate future users such as the Lunar/Mars mission. Contact:

William M. Cirillo
(804) 864-1938

Operation for Space Station Freedom Evolution — Study of the operations required by the growth of the Space Station from the baseline configuration. Contact:

George G. Ganoe
(804) 864-1940

Subsystem Growth Requirements for Space Station Freedom — Definition of the requirements on the Space Station distributed systems to allow station growth beyond the baseline configuration. Contact:

Barry D. Meredith
(804) 864-1960

The Use of CAD/CAE Systems in Analysis of Space Station Freedom Evolution —

Use of specific computer aided design and computer aided engineering systems to analyze station growth configurations for feasibility. Contact:

Patrick A. Troutman
(804) 864-1954

In-Space Technology Experiments —

Definition and development of flight experiments for the verification and/or validation of unique, innovative space technologies in the space environment or under microgravity conditions. Contact:

Lenwood Clark
(804) 864-1934

Joseph B. Talbot
(804) 864-1933

Lewis Research Center

Program Administrator

Dr. Francis J. Montegani
 Chief, Office of University
 Affairs
 Mail Stop 3-7
 NASA Lewis Research
 Center
 Cleveland, OH 44135
 (216) 433-2956

The Lewis Research Center has a broad research program embracing aeronautical propulsion, space propulsion and power, space electronics, and microgravity science. Brief descriptions of some of the major research activities at Lewis follow:

Aeropropulsion Analysis

Aircraft Propulsion Systems Analysis — Advanced propulsion concepts are analyzed to estimate performance for typical flight vehicle applications, determine relative merits compared with alternative propulsion systems, and derive optimum designs of systems integrated with a vehicle. Also conduct propulsion system sensitivity studies to identify deficiencies in existing technologies to guide the development of new NASA technology programs.

Contact: Daniel C. Mikkelson
 (216) 433-5637

Instrumentation and Controls Technology

Instrumentation — Instrumentation is developed for aerospace propulsion R&D requirements. Emphasizes laser-based techniques for nonintrusive gas path diagnostics and structures measurements, thin film sensor technology for temperature, heat flux, and strain measurements, and optical and electro-optical sensors and systems for propulsion and flight control applications. Silicon carbide-based solid-state electronic device technology for high temperature, high frequency, and high power applications is also being developed.

Contact: Norman C. Wenger
 (216) 433-3730

Controls Technology — Advanced digital electronic controls and systems for both airbreathing and rocket engines, motivated by increased performance and durability requirements. Included in the scope of the research are control theory applications, system dynamics, realtime propulsion system simulation, integrated flight/propulsion controls, fiber-optic and electro-optical control components, and robust fault tolerant controls and systems and neural networks to controls is an active research area.

Contact: Norman C. Wenger
 (216) 433-3730

Internal Fluid Mechanics

Computational Fluid Mechanics

New techniques for analysis of subsonic, supersonic, and hypersonic aerospace propulsion system flows associated with inlets, nozzles, compressors, turbines, combustors, augmentors, and rocket systems. Research is also conducted in the numerical simulation of fluids in the space environment, including such phenomena as rarefied gas flows, microgravity effects on free surfaces, g-jitter effects on fluid mixing, and microgravity combustion. Emphasis is on numerical methods with greater accuracy and significantly increased convergence rates. Of increasing importance are computational strategies using such concepts as multiblock grids and zonal approaches combining two or more numerical methods. Pacing items for advanced applications are three-dimensional complex geometry mesh generation techniques, grid lattice construction, and solution-adaptive mesh clustering. Three-dimensional turbulent flow fields with emphasis on turbulence models are of continuing interest. An expanded and focused effort on developing, validating and applying advanced turbulence models for propulsion flow physics is a growing research activity.

Contact: Lonnie Reid
(216) 433-3606

Experimental Fluid Mechanics

Experiments to verify selected fluid mechanics computations and to advance understanding of flow physics, heat transfer, and combustion processes fundamental to aerospace propulsion. Experimental data are analyzed to aid development of aerothermodynamic models embracing combustion thermodynamics, reaction chemistry, and turbulence. State-of-the-art experimental facilities, instrumentation, and data acquisition, reduction, and analysis methods and facilities are employed.

Contact: Lonnie Reid
(216) 433-3606

Computational Technology

Development and application of advanced computer hardware and software to the simulation of flows associated with aerospace propulsion components and systems. Included in the scope of the research are the synthesis and benchmarking of parallel computer architectures and algorithms for solving 3-D steady and unsteady flow problems, the use of expert systems as intelligent interfaces to large computer codes, the use of parallel processing and interactive graphics techniques for on-line visualization of computational results and experimental data, and improved data handling software for distributed computing environments.

Contact: Lonnie Reid
(216) 433-3606

Aeronautical Propulsion Systems

Aircraft Icing

Analytical and experimental efforts devoted to developing novel concepts for aircraft ice protection. Fundamental experiments to understand and model the physics of ice formations. Changes in aircraft performance with ice build-up on unprotected components are quantified. Extensive aerodynamic and thermodynamic numerical models are developed and utilized. Interdisciplinary efforts are devoted to developing instruments to characterize icing cloud properties, measure ice accretion on surfaces, and detect changes in aircraft performance in icing conditions. Experimental research is conducted with a specially equipped Twin Otter aircraft and in the Lewis Icing Research Tunnel, the largest refrigerated icing tunnel in the world.

Contact: John J. Reinmann
(216) 433-3900

Propeller Aerodynamics and Acoustics

Analytical and experimental investigations of the aerodynamics and acoustics of advanced propellers for flight Mach numbers to 0.8. Advanced lifting line and finite difference lifting surface methods are applied to the prediction of the flow fields and performance. Noise predictions are made using time and frequency domain acoustic analogy models in conjunction with aerodynamic predictions. New propeller concepts are evaluated analytically, and the more promising are evaluated experimentally for performance and noise characteristics.

Contact: John F. Groeneweg
(216) 433-3945

Aircraft Power Transfer Technology

Power transfer technology for advanced propulsion drive systems having higher power-to-weight ratio, longer life, higher reliability, lower noise, and higher efficiency. Areas under study include design optimization, new gear arrangements and tooth forms, materials, lubrication, and cooling. New analytical tools for stress analysis, vibration, lubrication, and high speed gears are being developed. A full-scale helicopter transmission test rig is available as are facilities for fundamental studies of lubrication, endurance, efficiency, noise of spur and bevel gears, and planetary gear sets.

Contact: John J. Coy
(216) 433-3915

Turbine Engine Technology

Research to advance gas turbine engine technology for wide range of civil and military applications. Areas addressed include advanced cycles involving regenerators and recuperators, advancement of compressors, combustors, and turbines, and application of ceramic materials. Involved are flow visualization, computer code development, performance modeling, and thermal and mechanical technologies.

Contact: Clavin L. Ball
(216) 433-3397

High Performance Aircraft Propulsion Technology

Research on propulsion systems for advanced high performance aircraft including highly maneuverable fighters and short takeoff/vertical landing fighters. Included are theoretical analyses and experimental investigations of individual components and complete systems. Highly integrated flight propulsion control systems are a special area of investigation. Novel propulsion concepts are evaluated and research performed to develop key technologies. Research includes analytical studies, application of advanced design codes, and planning and execution of experimental programs.

Contact: Peter G. Batterton
(216) 433-3912

Hypersonic Propulsion Technology

Analytical and experimental research directed at the aerodynamic design of hypersonic propulsion systems and their integration with the airframe. Work includes analysis and test of inlets, nozzles, combustors and other critical components. Experimental efforts include design of models and instrumentation. New theoretical flow analyses, which include 3-D shock/boundary layer interactions, are applied to the design and evaluation of experiments.

Contact: Robert E. Coltrin
(216) 433-2181

Materials

Metal Matrix and Intermetallic Matrix Composites

Advanced materials, such as intermetallic compounds and refractory metals, coupled with innovative processing concepts, such as rapid solidification, arc spraying, and laser fiber growth, are being developed for application to aerospace propulsion systems and space power systems having improved performance, higher temperatures, greater durability, and lower cost. Microstructure/property relationships are being developed and experimentally verified. Advanced analytical and microscopy techniques are employed.

Contact: Hugh Gray
(216) 433-3230

Polymers and Polymer-Matrix Composites

New generation of composite materials for application to advanced aerospace propulsion systems and airframes, and space power systems and structures. Areas of research include polymer synthesis, fiber characterization, processing, fiber/matrix degradation mechanisms, and environmental effects. The effort spans the range from fundamental inquiry at the molecular level to employment of composite material systems in final applications. The research is supported by facilities for Fourier transform infrared and nuclear magnetic resonance spectrometry, and thermogravimetric and differential thermal analysis.

Contact: Michael A. Meador
(216) 433-3228

Ceramic-Matrix Composites

Structure/processing/property relationships of ceramic-matrix composites for high-temperature, high-reliability requirements for advanced aerospace propulsion and power applications. New processing approaches, including polymer pyrolysis, chemical vapor deposition, and sol-gel processing are being pursued. Properties of interest include flaw distribution, phase morphology, strength, toughness, crack initiation and propagation characteristics, and resistance to environmental attack.

Contact: Stanley R. Levine
(216) 433-3276

Microgravity Materials Science

A fundamental understanding of the effect on materials processing of gravity as it influences convection, buoyancy, sedimentation, and hydrostatic pressure. Central to this effort is the Microgravity Materials Science Laboratory which is used by scientists to develop experiments for eventual flight on the Space Shuttle. The laboratory develops advanced flight hardware and supporting equipment for processing and analysis of metals, ceramics, glasses, and polymers. Areas of research include directional solidification, telerobotic

control, flow diagnostics, macro- and microsegregation, undercooling, sol-gel and containerless processing, and crystal growth. A significant portion of this effort is being directed to computational modeling of growth processes as they are influenced by gravity. The laboratory includes an extensive computational and graphical display facility.

Contact: Thomas K. Glasgow
(216) 433-5013

Tribology

Research to gain a fundamental understanding of lubrication, adhesion, and wear phenomena of materials in relative motion that meet increased speed, load, and temperature demands of advanced aerospace propulsion and power systems. Both synthesized liquid lubricants and solid lubricants created by plasma film deposition techniques are under study. Tribological behavior is investigated in situ using a variety of techniques including Auger electron and X-ray photoelectron spectroscopy.

Contact: Stephen V. Pepper
(216) 433-6061

Structures

Structural Analysis and Life Prediction

Structural analysis methods for advanced aerospace propulsion and power systems. Areas of consideration include finite element modeling, aeroelasticity, rotor and structural dynamics, fracture mechanics, life prediction, modeling of advanced materials including fibrous composites, micromechanics of high temperature fatigue, and damping. Analytical and experimental efforts are devoted to nonlinear constitutive relations for predicting the behavior of materials and components under varying loads and temperatures. Other topics include crack propagation and fracture criteria for mixed mode loading and variable temperature, transient thermal growth, and thermal bowing and its effects on clearances and unbalance.

Contact: John L. Shannon, Jr.
(216) 433-3211

Structural Dynamics

Fundamental methods for predicting and controlling the dynamic response and stability of aerospace propulsion and power systems. High-speed rotation provides a central focus for much of the work. This includes studies of the aeroelastic response of bladed disk systems, both active and passive methods for controlling the vibration and stability of high speed-rotor-shaft systems, and modal analysis methods for highly damped large scale periodic structures. Actively controlled bearing supports are being developed to allow higher speed and lighter weight aeropropulsion system design. Robotic systems are also being developed for use in microgravity Space Station laboratories. Innovative computational methods that exploit parallel computers and modern computer science principles are being applied.

Contact: L. James Kiraly
(216) 433-6023

Structural Integrity

Research to assure integrity and reliability of aerospace propulsion and power systems and structural components. Areas of emphasis include interrogational methods for avoiding catastrophic fracture, fault-tolerant design, defect assessment, and residual life prediction. Comprehensive life prediction models are sought that incorporate complex stress states, nonlinear material characteristics, microstructural inhomogeneities, and environmental factors. Structural integrity is verified by nondestructive characterization of microstructure, flaw population, material morphology, and other relevant factors. Nondestructive evaluation is carried out using analytical ultrasonics, computed tomography, laser acousto-ultrasonics, and other advanced interrogational technologies. Modern computer science practices are exploited to the fullest, and emphasis is on advanced structural ceramics and composites. Integrated computer programs for predicting reliability and life of brittle material components are generated.

Contact: John P. Gyekenyesi
(216) 433-3210

Probabilistic Structural Mechanics

Research for developing probabilistic structural mechanics, solution/computational algorithms, and requisite computer codes to quantify uncertainties associated with the parameters and variables required for structural analysis and design for both serial and parallel composites. Research focuses mainly on developing probabilistic theories and models for coupled thermal-mechanical-chemical-temporal structural behavior of propulsion structures made from high temperature materials and including metal matrix, ceramic matrix, and carbon-carbon composites.

Contact: Christos C. Chamis
(216) 433-3252

Advanced Composite Mechanics

Research for development of theories, computational algorithms, and requisite computer codes for the mechanics, analysis, and design of propulsion structures made from high temperature composites. Of interest are polymer matrix, metal matrix, ceramic matrix, and carbon-carbon composites. Research focuses mainly on specialty finite elements for micromechanics and laminate theory, improved theories for life and durability prediction under hostile environment and long time exposure effects, probabilistic composite mechanics, and integrated computer programs for component specific analysis and design, progressive fracture, and high-velocity impact. Selective experimental research is conducted in support of theoretical developments.

Contact: Christos C. Chamis
(216) 433-3252

Space Propulsion Technology

Liquid Rocket Propulsion

Research devoted to a better understanding of the basic physical and chemical processes involved in liquid rocket engines in order to provide technology for the next generation of liquid-fueled space propulsion systems. Disciplines include high-energy propellant

chemistry, ignition, combustion, heat transfer and cooling in thrust chambers, nozzle flow phenomena, and performance. Of particular interest are the fundamentals involved in combustion instability, metallized propellants, planetary *in-situ* propellants, expert system applications to propulsion, and non-intrusive diagnostics. Concepts are evaluated at the system level to determine engine and vehicle performance impact. The work is conducted through detailed analytical and experimental programs to determine feasibility or applicability and to develop and validate models to describe the processes.

Contact: Ned P. Hannum
(216) 433-2457

Low Thrust Propulsion Fundamentals

Research on electric and chemical propulsion concepts that are candidates for a broad range of low-thrust, space propulsion functions. The electric propulsion effort includes arcjets and a variety of advanced plasma rockets. The low-thrust chemical propulsion effort is focused on very high-performance storable and hydrogen/oxygen rockets at thrust levels up to about 100 pounds. Efforts are directed toward understanding the fundamental phenomena of the various concepts. State-of-the-art flow visualization, plume diagnostics, and other research tools are used to provide spatially and temporally resolved information on the critical thruster element such as the vortex/plasma flow fields of arcjets, the electrode/plasma relationships of MPD thruster, the combustion/mixing fluid physics and heat transfer of small chemical rockets, and the plumes of all the rocket concepts. In general, the results are used as input to formulation of predictive technology, such as three dimensional Navier-Stokes models. Ultimately, self-consistent models of low-thrust propulsion concepts are desired, which will allow prediction of thruster behavior and stability as a function of configuration and operating condition.

Contact: David C. Byers
(216) 433-2447

Rocket Engine System Monitoring

Research to develop improved methods for detection of anomalous behavior of rocket engines, to develop techniques for isolating the causes, and to automate these procedures. Research efforts are currently focused on the Space Shuttle Main Engine for which an Advanced Safety System and a Post-Firing Expert System based diagnostic capability are being developed. Research opportunities include development of qualitative and quantitative rocket engine models for failure signature prediction, application of neural networks and pattern recognition techniques for diagnosis, and construction of expert systems and user interfaces.

Contact: Sol H. Gorland
(216) 433-2449

Power Technology

Photovoltaic Space Systems

Fundamental and applied research to increase the efficiency, reduce the weight, and extend the life of solar cells for space applications. Emphasis is on III-V compounds, i.e., InP and GaAs. However, amorphous silicon and other thin film materials systems are also of interest. Activities include materials studies, investigations of radiation damage effects, device design, fabrication and testing and the development of related component technologies such as interconnects and optical concentrators.

Contact: Dennis J. Flood
(216) 433-2303

Electrochemical Space and Storage

Advanced technology to increase the life and energy density of energy storage systems and fuel cells. Emphasis is on nearer-term nickel-hydrogen and hydrogen-oxygen systems, with exploratory efforts being given to more advanced high-temperature ionic conductor systems. Pre-prototypes of advanced battery systems are being designed, built, and tested.

Contact: Marvin Warshag
(216) 433-6126

Space Power Management and Distribution Technology

Technology to control the generation and distribution of electrical energy in space systems and to define enabling technology for future high-power space systems. The program includes the investigation of advanced electrical power circuits and the fundamental physics of electrical devices (insulators, conductors, and semiconductors). Prototype devices and circuits are fabricated and performance characterized and analyzed. Research in system autonomy, system architecture, and fault prediction are important elements of the program.

Contact: Robert W. Bercaw
(216) 433-6112

Power Systems Technology

Technology for efficient, compact, lightweight, long-life nuclear space power systems for a variety of applications over a range from 5 kilowatts to 10s of megawatts. Power generation, energy storage and electrical power management technology for extraterrestrial solar surface power systems. System and mission application studies for nuclear and solar space power systems are conducted to identify requirements and technology needs in the areas of energy conversion, thermal management, power conditioning and control, materials and environmental effects.

Contact: John M. Smith
(216) 433-6130

Thermal Management Technologies for Space Power Systems

Analytical and experimental efforts to develop lightweight space radiator components and to tailor individual cycle operating conditions to achieve optimum subsystem matching and lowest overall system mass. Radiator designs must resist a variety of natural hazards including micrometeoroids and space debris. Concepts under investigation include designs utilizing lightweight carbon-carbon heat pipes with high conductivity carbon-graphite fins and immiscible binary fluid pumped loops. Innovative concepts, such as the liquid sheet radiator, are also being explored.

Contact: James E. Calogeras
(216) 433-5278

Solar Dynamic Systems for Space Power

Advanced development of solar dynamic technologies for light weight, high performance space power systems. The application of highly reflective concentrator surfaces on light weight substrates minimize overall mass. For long life, both surface and substrate must resist environmental effects such as atomic oxygen and space radiation. The development of high conductivity thermal energy storage materials in innovative heat pipe receiver designs decrease the size and weight of the system.

Contact: James E. Calogeras
(216) 433-5278

Stirling Dynamic Power Systems

Technology to exploit the unique potential of the Stirling engine for both space and terrestrial applications. Principal emphasis is on developing the free-piston Stirling engine for high-capacity space-power generation systems. Among the areas of research are oscillatory flow and heat transfer, advanced instrumentation, heat pipes, high temperature materials, gas bearings, dynamic balancing systems, and hydraulic and linear alternator power takeoff systems.

Contact: James E. Dudenhoefer
(216) 433-6140

Space Environmental Interactions

Research on electrostatic and electromagnetic effects induced in space systems and instrumentation by interaction with space plasma and field environments and on the development and characterization of local plasma and field environments around large space systems. Such effects include surface and bulk dielectric charging, plasma sheath development and characteristics, current collection from plasma, arcing, and the stimulation and propagation of disturbances. Research disciplines involved include plasma, solid state, and surface physics, electromagnetism, and fundamentals of space system design.

Contact: Carolyn K. Purvis
(216) 433-2307

Space Power Materials

Research on thermally conductive, high-strength composite materials with either very low or very high electrical conductivity for high-performance applications requiring light weight. New and improved materials are investigated for use as insulators, conductors, reflective surfaces, thermal control coatings, thermal radiators, and atomic oxygen protective coatings. Research is also conducted to enable fabrication, characterization, functional performance, and durability evaluation of the materials.

Contact: Bruce A. Banks
(216) 433-2308

Space Experiments

Microgravity Science and Applications

Basic science experiments designed to capitalize on the microgravity environment of the Space Shuttle in the areas of combustion, metals and alloys, fluid physics and transport phenomena, ceramics and glasses, and electronic materials. Science requirements and conceptual designs are developed using ground-based 2.2 second and 5 second drop towers and a Learjet aircraft. Activities culminate in the design, fabrication, and flight of space experiments.

Contact: Jack A. Salzman
(216) 433-2868

In-Space Technology Experiments

In-space experiments to support advancement of the technology base in the areas of fluid management, energy systems and thermal management, and satellite communications. Areas of investigation include on-orbit fuel storage and transfer, low-gravity fluid behavior and thermal processes, instrumentation, and spacecraft fire safety. While ground-based

precursor studies are pursued, emphasis is on the definition and development of cost-effective flight projects that yield results otherwise unobtainable through ground-based experiments or analysis.

Contact: Jack A. Salzman
(216) 433-2868

Space Communications Technology

Space Communications Systems Analysis

Studies of advanced space communications systems to define future technology requirements. Such studies include investigation of new communications system architectures and net-working concepts, comparison of advanced satellite and terrestrial systems, and exploration of new ways to increase the available spectrum/orbit communications capacity. Involved are computer modeling of systems of satellites and simulation of communications links. Laboratory research is conducted on digital coding schemes to reduce bandwidth requirements for information transmission.

Contact: Edward F. Miller
(216) 433-3479

Space Communications Components

Research to establish the technical feasibility of advanced satellite communications components including electron beam devices, solid state devices, and antennas. Electron beam device research is focused on traveling wave tubes operating to 100 GHz and embraces materials and fabrication, electron guns, beam wave interactions, efficiency enhancement techniques, and submillimeter wave sources and components. Solid state device research is focused on monolithic microwave integrated circuit (MMIC) devices for advanced transmitter and receiver modules. Areas of interest include wave transmission media, circuit analysis and synthesis, device modeling, microfabrication technology, and crystal

growth techniques. Antenna research includes theoretical and experimental investigation of advanced multibeam systems operating at microwave and millimeter wave frequencies. Work is focused on the use of MMIC modules in multiple feed elements and the use of such feeds to dynamically compensate for distortions by controlling phase and amplitude.

Contact: Denis J. Connolly
(216) 433-3503

Satellite Communications Systems Technology

Advanced satellite communications system and subsystem technology to establish performance and cost data necessary to demonstrate readiness for operational application. Specific technologies being developed include antennas and antenna feeds, low noise amplifiers, RF power amplifiers, IF and RF switching systems, modems, communication processors, and network control techniques.

Contact: James W. Bagwell
(216) 433-3503

Aerospace Applications of High-Temperature Superconductivity

Research to assess the potential payoff for aerospace applications of high-temperature superconductivity (HTS), to define the technology requirements for these applications, and to develop the requisite technology. Emphasis will be placed on the large scale applications generally involving high currents, high magnetic fields, and substantial energy storage or power transmission.

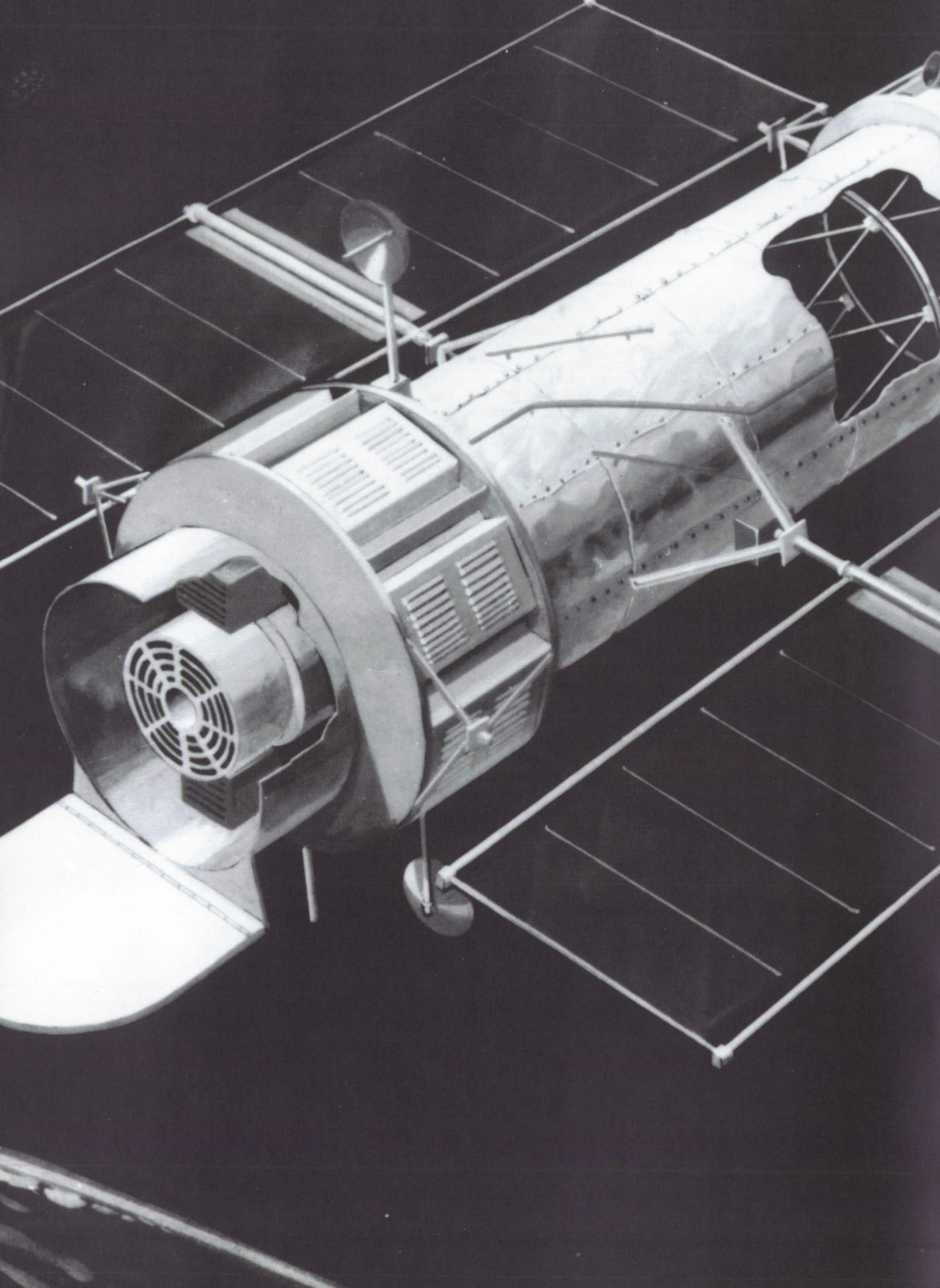
Contact: Denis J. Connolly
(216) 433-3503

Advanced Space Analysis

Lunar/Mars Exploration

Advanced planning; performance of system level trades in propulsion, power, cryogenic fluids, space transportation, and communications; and mission analyses. ASAO activities promote and establish new frontiers for Lewis Research Center, and pro-actively support the Agency in the arena of the Lunar/Mars Exploration Program initiated by President Bush on July 20, 1989. Mission planning and systems analytical capabilities currently are being sought. Advanced Space Analysis Office activities span both center and agency needs, and draw on expertise and resources from across the country.

Contact: Donald T. Palc
(216) 433-2646



George C. Marshall Space Flight Center

Program Administrator

Dr. Frank Six
University Affairs Officer
NASA Marshall Space Flight
Center
Mail Code DS01
MSFC, AL 35812
(215) 544-0997

The Marshall Space Flight Center offers opportunities for original work in many areas of the physical sciences, mathematics, and engineering. Theoretical and experimental research is greatly enhanced by the ready access to computers, including the Cray XMP.

Before preparing your proposal, prior discussion with a center researcher is recommended. In general, Marshall advisers are interested in collaborative efforts with students and their university advisers and will look favorably on proposals indicating some research time will be spent on-site at the center.

Information and Electronic Systems Laboratory Electrical Systems

Activities include development of advanced silicon devices utilizing diffusion and ion implantation techniques, high solar concentration photovoltaic systems, and electrical power system automation techniques. Research is conducted in planar and concentrator array development, and improved efficiency photovoltaic cell design, cell modeling, and performance testing. On-site resources include semiconductor processing facilities for cell and material development, and a photovoltaics test laboratory complete with solar simulator and vacuum chamber for simulation of on-orbit conditions. Artificial intelligence approaches are used to support electrical power system automation, address autonomous fault management, dynamic payload rescheduling, intelligent data reduction, autonomous battery management, and enhanced state-of-health monitoring and reporting.

Contact: R. Bechtel (205) 544-3294

Electronics, Sensors, Robotics

Research, design and development activities are conducted on electronic control systems and measurement sensors for guidance, navigation, and control of space vehicles, orbiting spacecraft and planetary exploration vehicles, and on robotics and teleoperator systems. A wide variety of subjects is addressed, such as rate gyros, accelerometers, star trackers, sun sensors, strain gauges, pressure sensors, control moment gyros, reaction wheels, and pointing systems. Robotics is a major area of concentration. Rendezvous and docking of vehicles in orbit, both teleoperated and automated modes, is studied and demonstrated in the flight robotics facility. This facility, a broad-based testbed, is used for concept study, development, and testing in the areas of space orbital and robotics operations. On-orbit servicing is a related effort. Camera placement, force torque sensing, lighting, and robotic vision are all

study areas for which the facility is used. Control station work involves research in the use of voice recognition, touchscreens, and stereo vision.
Contact: E.C. Smith (205) 544-3506

Optical Systems

Opportunities exist for research, design, and development of optical, laser doppler, video, and electro-optic image and detection device technology for application in future or proposed missions.
Contact: J. Bilbro (205) 544-3467

Software and Data Management

An area of high interest is the automatic generation of digital computer code from structured requirements. An area of particular interest is to use knowledge-based systems to implement software progressions automatically from requirements phase through code generation for embedded computer systems. Another target area of research and development is Artificial Intelligence techniques and tools to aid in fault diagnosis, load management, and scheduling for flight systems and subsystems.
Contact: D. Aichele (205) 544-3722

Materials and Processes Laboratory

Major technology and research efforts are underway in physics and chemistry of materials, both metallic and nonmetallic, and in critical environments at cryogenic to high-temperature levels. Comprehensive research and development activities are pursued in qualification and testing of materials.

Space Environmental Effects on Materials

Evaluation of materials is accomplished in space environmental conditions involving vacuum, temperature, electron/proton, atomic oxygen, and micrometeoroid impact. The effects of outgassing products of materials on weight loss, strength loss, surface properties, and re-deposition and condensation on other items is being studied. Lubrication and surface physics on bearings in space and in rocket propulsion components is under research. Nondestructive evaluation (NDE) research and development in new NDE methods/processes and instrumentation is encouraged.
Contact: A. Whitaker (205) 544-2510
P. Schuerer (205) 544-2566

Metallic Materials Research

Development of alloys for special application such as blades and discs in hydrogen or oxygen turbopumps, fuel tanks, solid rocket motor cases, etc., is an ongoing requirement. Research in metallographic micro-structural analysis methods to determine the condition and history of certain alloys is being accomplished in support of failure analyses and fracture mechanics research. Methods for quantitatively determining the state of corrosion, stress corrosion and hydrogen embrittlement of alloys are being developed. Research is also directed at characterizing the properties of alloys in simulated service environments and enhancing alloy performance through modifications in chemistry, processing, or surface treatment. Available state-of-the-art research facilities include mechanical testing laboratories; a high pressure, high temperature, gaseous hydrogen, materials testing laboratory; corrosion research laboratories; a foundry and thermal processing laboratory, and a metallurgical and failure analysis laboratory equipped with modern diagnostic systems for micro-structural and surface chemistry analysis.
Contact: P. Munafa (205) 544-2566

Nonmetallic Materials Research

Opportunities exist to develop and modify polymers for adhesives, insulators, elastomers, composite matrices, and molding and extrusion compounds for use in spacecraft hardware and in special environments. Organic composites such as carbon-carbon or carbon-resin are being developed for structural applications to reduce mass or for high temperature applications such as rocket engine nozzles and leading edges. Ceramics and glasses with special optical properties and high strength and toughness for structural properties in spacecraft are continually sought.

Contact: C. McIntosh (205) 544-2620

Processing Engineering Research

A Productivity Enhancement Center employs new and improved techniques for developing manufacturing processes to produce spacecraft hardware. This center uses graphics computers/terminals to lay-out work by Computer Aided Design, Computer Aided Manufacturing, and Computer Integrated Manufacturing. Remote programming of machines and robots to improve filament winding patterns, automatic weld paths, and foam spray are just a few applications in process. Welding by new techniques, such as the variable polarity plasma arc process on special alloys and use of smart robots to accomplish intricate welds, is being researched.

Nonmetallic processing such as filament winding, pultrusion, tape laying, tape wrapping and hydroclave curing to achieve optimum properties in composites is the subject of intensive research and development.

Contact: M. H. Sharpe (205) 544-2714

Propulsion Laboratory

Activities are directed toward the research, technology, and flight hardware development of propulsion systems for launch and space vehicles and support equipment. Areas of activity include liquid and solid propulsion and control systems for the Space Shuttle, space propulsion and support systems, advanced chemical and laser propulsion systems for future launch and space vehicles, and flight experiment and space station mechanisms.

Systems Division

Research and development is ongoing in liquid rocket engines, solid motors, propulsion systems, and reaction control systems. Activities include predicting, analyzing, and evaluating propulsion system and launch vehicle performance, and establishing test, integration, and verification requirements for flight and test bed propulsion systems. There is continuing interest in solid and liquid propellant combustion, performance prediction, engine risk management, launch and space vehicle propellant and pressurization systems, hybrid (solid/liquid) boosters, pressure fed boosters, laser propulsion, and advanced engine control and monitoring subsystems. Special emphasis areas for research are zero- and low-gravity propellant systems and combustion.

Contact: J. Redus (205) 544-7051

G. Platt (205) 544-7106

Component Development Division

Activities involve research and development for mechanical subsystems such as propulsion feedlines, turbomachinery, combustion devices, thrust vector control, auxiliary propulsion, valves, actuators, controls, mechanisms, and environmental control and life-support hardware. Another area of interest is establishing test, integration, and verification requirements for mechanical elements.

Contact: C.S. Cornelius (205) 544-7130

Combustion Devices and Turbomachinery

Investigation of the combustion stability, along with performance and heat transfer, of large hydrocarbon-fueled rocket engines are of special interest for the development of a new booster engine. Techniques for understanding the failure and wear modes and improving the life of propellant cooled antifriction bearings are needed for reusable rocket engines.

Contact: G. Young (205) 544-7070

Control Mechanisms

Facilities exist that give unique high-flow/high-pressure hydraulic test capability combined with dynamic load simulators for testing a wide range of electrohydraulic servoactuators and fluid power subsystems.

Opportunities exist for research in the design and development of fluid power systems for thrust vector control of rocket engines.

Contact: J. Harbison (205) 544-7143

Test Division

Activities include experimental research and development testing of propulsion systems, subsystems, and components for space systems hardware. Current specific areas of interest relate to automated test control systems. A continuing interest exists for new and advanced instrumentation techniques.

Contact: R.L. Thompson (205) 544-1247

C.L. Robinson (205) 544-1169

Space Science Laboratory

Magnetospheric and Plasma Physics

Research is centered around 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, medium-energy plasma responsible for auroral phenomena, interactions between these plasma populations, and resulting effects on the upper atmosphere. Activities include design, development, and calibration of flight instrumentation and analysis and interpretation of resulting data. Contact: T. Moore (205) 544-7633

Aeronomy

Research in this area is aimed at understanding the Earth's middle and upper atmosphere. Experimental programs are underway featuring remote sensing in the vacuum ultraviolet, visible and near-infrared, including instrumentation on Shuttle, satellites, stratospheric

balloons, and ground sites. An important aspect is development of advanced optical and focal plane detection systems for exploring the physics and chemistry of this region from space platforms.

Contact: M. Torr (205) 544-7676

Solar Physics

The influence of the magnetic field on the development and evolution of solar atmospheric structure is studied. The primary data are vector magnetograms obtained at Marshall's Solar Observatory. These observations are complemented by theoretical studies to characterize the non-potential properties of these fields. This includes the development of MHD (magnetohydrodynamic) codes designed to simulate both coronal and large scale interplanetary dynamics. Instrument development programs in optical polarimetry, grazing and normal incidence x-ray optics, and imaging detectors are being pursued.

Contact: J. Davis (205) 544-7600

X-Ray Astronomy

Theoretical and experimental research is conducted in the fields of X-ray astronomy and high-energy astrophysics. Specialities include study of neutron stars, active galactic nuclei, and imaging X-ray detectors operating from 1/4 keV to 100 keV. Opportunities include participating in balloon flights of these detectors, theoretical studies of physical processes near compact objects, and analysis of data from the Einstein (HEAO2) and EXOSAT satellites.

Contact: M. Weisskopf (205) 544-7740

Gamma Ray Astronomy

Gamma ray astronomy is performed with balloon-borne and orbiting instruments designed and developed at MSFC. The research includes experiments covering the 30keV to 10 MeV region to study gamma ray bursts and other transient sources, and to study the gamma ray continua from known sources. Present activities include the development of the Burst and Transient Source Experiment to fly on the Gamma Ray Observatory, and balloon-borne observations of SN 1987A and the galactic center region with a high resolution detector system. A study of the local gamma ray background in the atmosphere and on spacecraft is in progress with calculations and with measurements on Spacelab, LDEF, and other spacecraft. Laboratory studies of future detector systems for gamma-ray astronomy are in progress.
Contact: G. Fishman (205) 544-7691

Cosmic Ray Research

Cosmic ray research emphasizes the study of the chemical composition and energy spectra of cosmic ray nuclei above 500 billion electron volts. Study of the interactions of heavy cosmic ray nuclei is also carried out above this energy to determine the differences between nucleon and nucleus interactions at very high energies and to search for evidence of new states of nuclear matter (e.g., chiral symmetry restored state). The research is carried out principally with emulsion chambers, occasionally in tandem with electronic counters to select categories of events. The instruments are exposed on balloons at about 4100 m (125,000 feet) for up to 2 weeks. Research includes laboratory work with passive and electronics detectors, data analysis, particle cascade calculations, and correlative accelerator experiments.

Contact: T. Parnell (205) 544-7690

Infrared Astronomy

Astronomical research is carried out in close coordination with the development of IR sensors. The sensors, which span the spectral region between 1 and 30 micrometers are used at major telescopes to produce unique images of comets and regions of star formation in our own and other galaxies. These data provide clues to cometary structure, origin, and long-term evolution.

Contact: C. Telesco (205) 544-7723

Cryogenic Physics

Experimental and theoretical research is conducted on cooled sensors for advanced space science experiments and cooling systems to support the sensors. Stored cryogens and their containment systems are developed, as well as active refrigeration systems extending both to sub-Kelvin temperatures needed by infrared bolometers and conventional superconducting electronic devices, and to higher operating temperatures required by high critical temperature superconducting electronic devices. Sensor research includes conventional and superconducting infrared detectors and arrays for cometary and galactic astronomical observations, and superconducting devices such as cooled gyroscopes, electronic devices, and sensitive accelerometers, in support of gravitational physics program. Well-equipped laboratories exist to support research on improved superconducting materials and sensors.

Contact: E. Urban (205) 544-7721

Low-Gravity Science

Theoretical and experimental research is conducted on the effects of gravity on the crystal growth or solidification of materials including semiconductors, metals, alloys, proteins, polymers, model systems, etc. Both the preparation and the characterization of

materials are important. The areas of research include solid-state physics, surface physics, solidification phenomena, separation techniques, fluid modeling, analysis of crystal growth, and characterization techniques such as optical, X-ray, and electron microscopy. In addition to well equipped laboratories for these activities, the division operates a drop tube and drop tower each 100 m high. Contact: F. Szofran (205) 544-7777

Biophysics

An opportunity exists to conduct research in the separation and purification of biological cells and proteins to develop basic understanding of the separation phenomenon. The proposed research should include analysis of the fundamental behavior of a separation process by theoretical and/or experimental methods. A second activity involves laboratory and space experiments in protein crystal growth. High quality single crystals are required to obtain the three-dimensional structure of the proteins, and Shuttle space experiments confirm the advantages of the microgravity environment. Projects include experiments to define improved crystallization conditions and the analysis of crystals by X-ray diffraction.

Contact: R. Snyder (205) 544-7805

Structures and Dynamics Laboratory

Structural and Dynamic Testing — Structural and dynamic testing of aerospace systems and components is ongoing. Development, acceptance, and qualification testing is performed in the disciplines of structural strength and dynamics, including modal, vibration, shock, acoustics, functional, and load. Control dynamics of large structures is also investigated, and various active and passive damping techniques are developed and tested.

Contact: C. Kirby (205) 544-1119

Systems and Components Test and Simulation

— Opportunities exist for the development, qualification, integration, and flight acceptance testing of space vehicles, payloads, and experiments. Neutral buoyancy simulations for training and development of Extra-Vehicular Activity (EVA) techniques are performed. Thermal vacuum testing is conducted in a variety of chambers with capabilities to 1×10^{-7} torr and temperature ranges from -300°F to $+400^{\circ}\text{F}$. Facilities exist to calibrate X-ray payloads and scientific instruments utilizing a 309-meter evacuated guide tube. Contact:

B. Dickson

(205) 544-1296

Neutral Buoyancy

R. Stephens

(205) 544-1336

Environmental Testing

C. Reily

(205) 544-1298

X-Ray Calibration

Crystal Growth in Fluid Field and Particle Dynamic Evaluation

— The Fluid Experiment System (FES) was developed to study low-temperature crystal growth of triglycine sulfate solution in a low-gravity environment. Incorporated into the FES is a laser/optical system for taking holograms of crystal growth, fluid density, and temperature variations. Tasks include applying holographic and digitized image techniques to evaluating these holograms.

Contact: J. Lindsay (205) 544-1301

Alloying Metals and Vapor Crystal Growth Evaluations

— Current investigative activities in the General Purpose Rocket Furnace (GPRF) Test Complex include the study of the macro- and micro- structures developed in liquid phase miscibility gap materials such as Aluminum Indium; the microgravity effects on vapor transport and crystal growth properties of electronic materials (germanium selenide and mercury-cadmium-tellurium) utilizing a temperature gradient to induce the necessary vapor transport of the source material; and the dendritic growth of alloys under

microgravity conditions. These studies are conducted with samples approximately 3 inches long and .75 inches in diameter which are processed in 1 3-element gradient furnace with each element controlled individually. The furnace capabilities are vacuum or inert gas environment with temperatures up to 950°C.

Contact: J. Lindsay (205) 544-1301

Pointing Control Systems — Anticipated tasks include pointing systems with performance in the order of one milli-arcsecond, the ability to actively control structures with several structural modes below the control frequency, the use of fiducial light systems and unobtrusive sensors/effectors to stabilize large space structures, development of the theory of many control systems working on the same flexible structure, the modeling, controlling, and verification of flexible multibodies that can undergo configuration changes, and momentum exchange control of very large objects.

Contact: H. Waites (205) 544-1441

Controls for Vehicles — Automatic or remote piloted precision recovery of objects from earth orbit, control system development for dynamic objects connected by low-tension tethers, control of aero-assisted tugs, and remote piloted controls for docking with uncooperative, dynamics objects are being investigated.

Contact: N. D. Hendix (205) 544-1451

Liquid Propulsion Dynamic

Analysis — Tasks include dynamic analysis, determination of damping methods, analysis of bearings, and dynamic balancing of high speed turbomachinery. Topics of interest in control include rapid recognition of engine failure, detecting incipient failure, automatic reconfiguration of control components, and more accurate means to control propellant mixture ratio.

Contact: P. Vallyely (205) 544-1440

Structural Dynamics — Activities of interest are aerostructural modeling, vibration analysis, and load predictions using simulation of all environments, including propulsion, control, aerodynamics, and atmosphere. Probabilistic, as well as deterministic, approaches are used on the CRAY to simulate flight and obtain loads data. Enhanced dynamic analysis techniques are pursued.

Contact: W. Holland (205) 544-1495

Structural Assessment — Opportunities exist for research in stress modeling and analysis, fracture mechanics, stability, and fatigue analysis. The CRAY computer is available for analytical analysis in conjunction with CAD/CAM work stations. Structural testing capability is extensive and can be used for research and development activities.

Contact: C. J. Bianca (205) 544-7182

Vibroacoustics — Mechanically and acoustically induced random vibration design and test criteria and response loads analytically derived using advanced computer techniques. Vibration, acoustic, and transient data from engine static firing and Space Shuttle flights are analyzed and categorized. Research opportunities include improved vibroacoustic environment prediction methods and high frequency vibration data reduction techniques.

Contact: H.J. Bandgren (205) 544-5714

Structural Design — Evaluation, concept selection, and design of composite intertank structure for reusable Heavy Lift Launch Vehicles. Plans are currently in place to fabricate and test subscale models of the resulting structure. Plans are being developed to initiate a similar program for the evaluation, selection, fabrication, and test of both reusable and expendable cryogenic tankage. A significant technology program in the area of spacecraft meteoroid and debris protection is underway. This problem area is of particular concern for large area, long-term on-orbit

spacecraft systems such as space station, in a gradually increasing debris environment. As part of NASA's Pathfinder program, we are currently performing concept evaluation, design, and functional testing of heavily loaded joints for on-orbit assembly of large space structures and Lunar/Mars mission vehicles. The challenge is to design joints that can be assembled with minimum or no Extra-Vehicular Activity (EVA).

Contact: P.I. Rodriguez (205) 544-7006

Thermal Analysis: Liquid Propulsion

Systems — Opportunities for research exist in thermal analysis of liquid propulsion system components, including integrated thermal/structural analysis of turbine blades and fluid/thermal modeling of bearing systems in high-pressure turbomachinery. Analytical results may be correlated to ground test data.

Contact: J. Owen (205) 544-7213

Thermal Analysis: Solid Rocket

Motor — Opportunities are available for research in thermal modeling and analysis of solid rocket motor thermal protection systems. Specific areas include the modeling of ablation processes involving a variety of material surfaces and the determination of heat transfer coefficients in radiative, erosive, and chemically reactive environments.

Contact: K. McCoy (205) 544-7211

Thermal/Environmental Computational

Analysis — Research opportunities are available in advanced thermal modeling and analysis techniques based on state-of-the-art graphics systems and software. Research is needed in methods of 3-D graphic modeling of thermal systems which are compatible with computational fluid dynamics and stress modeling.

Contact: J. Sims (205) 544-7212

Closed Loop Life Support — Development of innovative, efficient, and reliable techniques for performing environmental control and life support for future long-duration missions is underway. Emphasis is on improved processes for oxygen and water reclamation. Also of interest is long-life sensing of internal atmosphere state conditions, as well as monitoring of water and air quality conditions from physical, chemical, and microbial viewpoints.

Contact: W. Humphries (205) 544-7228

Computational Fluid Dynamics —

Opportunities to develop and apply state-of-the-art computational fluid dynamic (CFD) methods to solve three-dimensional highly turbulent flows for compressible and incompressible fluid states; and to provide benchmark CFD Comparisons to establish code quality for subsequent application. Research is needed to assess significant aspects of the computational algorithms, grid generation, numerical problem formulation, code efficiency, convergence rate, stability, etc.

Contact: L. Schutzenhofer
(205) 544-1458

Earth Sciences

Tropospheric Wind Profiling — Wind profiles to heights of 18 km and estimates of wind variability are critical inputs for launch vehicle design and actual launch decisions. To optimize vehicle performance, high temporal and spatial resolution is required for wind profile measurements. Currently, NASA uses Jimsphere balloons and a 50 Mhz radar wind profiler for wind profile measurements. Measured profiles are analyzed to produce a representative climatology and to study relationships between wind magnitudes, vertical shears, and spatial and temporal wind variability. Research is also directed to identifying wind profile characteristics that would be of benefit for the prediction of launch vehicle performance.

Contact: Steve Smith, (205) 544-5971

Stratospheric and Mesospheric Studies — Middle atmospheric (50-100 km) density must be accurately described to permit safe re-entry of the shuttles and space maneuvers. Satellite, rocket, balloon, lidar, radar and nightglow measurements are being assembled into a self-consistent dynamical atmospheric model. All scales of motions from seasonal to planetary waves to tides to gravity waves are important to vehicle and trajectory designers. Theoretical and empirical research efforts are examining such atmospheric waves and their interactions. A new pursuit in this area is the search for long term middle atmosphere variations. Contact: Steve Smith (205) 544-5971

Model Studies of Storm Electrical Processes — This research estimates the Maxwell current between discharges and the Wilson conduction current obtained during U-2 aircraft flights in 1986. The Maxwell current was found to vary linearly with total flash rate and thus could be estimated using data from the proposed Lightning Mapper Sensor. The Wilson conduction current which contributes to the global electric circuit, tended to level off with increasing flash rate. Recent efforts to gain a better understanding by modeling the U-2 observations provided extremely encouraging results (i.e. very good qualitative agreement was found between the observations and the model results). The modeling should now be extended to study more quantitatively the relationship between lightning rates and characteristics (e.g. charge transfers, percentage of cloud-to-ground, etc.) and the resultant currents. Again the application of this understanding will be in interpreting Lightning Mapper and Lightning Imaging Sensor data. Contact: Richard Blakeslee (205) 544-1652

Storm Electric Field Structure — This activity involves measurement of weakly convective storms as a function of radar reflectivity, updraft velocity, cloud microphysics, etc. The electrification process occurring in this family of clouds is determined in order to characterize the electrical energy generation rate as a function of the overall lightning discharge rate. These findings are related to simulated lightning mapper observations, demonstrating the applicability of lightning mapper data to the study of weakly convective and winter time electrical storms. Contact: Hugh Christian (205) 544-1649

Cloud Scattering of Lightning Discharges This task is to model the radiation viewed from space resulting from lightning discharges within clouds. This is an electromagnetic multiple scattering problem. The solution is given in terms of scattering amplitudes that take into account the propagation parameters of air, water and ice. Reciprocity relations for the scattering cross sections corresponding to an arbitrary direction of the incident wave. The interest of this work is in determining the relationship between cloud physics parameters, lightning discharges, and the remotely sensed signal to be viewed from space by the Lightning Mapper and Lightning Imaging Systems. Contact: Hugh Christian (205) 544-1649

Climate Modeling with the CM1 — This research effort is geared toward understanding the sensitivity of the climate model 1) to surface boundary forcing, i.e. sea surface temperature, albedo and soil moisture anomalies. Several experiments with different forcing will be compared to the control run climate. Extensive Cray usage (approximately 100 CPU hours) will be required. Comparison of results to observed atmospheric behavior will be carried out eventually using MSU, OLS and AVHRR satellite data. Contact: Dan Fitzgarrald (205) 544-1651

Physical Climate Analysis — Observational, numerical modeling and analytical approaches are used to study the Earth's physical climate system. Diagnostic analysis of space-based observations are used to understand and validate models of global hydrologic cycle. Numerical models ranging in scope from the atmospheric general circulation codes to mesoscale and cloud models are used to test analytical/conceptual models of the water cycle and its role in climate. Simulations of current and future remote sensors are used to understand how space-based observations can best be directed to studying the Earth as a system.

Contact: F. Robertson (205) 544-1655

Geophysical Fluid Dynamics and

Modeling — Much that is not well understood about the behavior of the Earth's atmosphere and oceans concerns the fundamental fluid dynamics of the system. Research is underway to develop and use models to understand the system, including laboratory models of a rotating, thermally driven fluid system, numerical models of such a system, and more detailed numerical models of atmosphere and its interaction with the underlying surface. The results from these modeling efforts will be used to guide the development of more sophisticated models of the geophysical system, as well as the development of space-based remote sensors and the utilization of satellite data.

Contact: T.L. Miller (205) 544-1641

Space Vehicle Environments — Research activities are underway to improve knowledge of the natural space environment to support engineering of advanced NASA missions such as Space Station Freedom and the Lunar-Mars Initiative. Emphasis is on study of the density, composition, and temporal variation of the Earth's thermosphere and mesosphere, and

the Martian atmosphere in general. The objective is to improve knowledge and empirical models of environments which impact the design of aerobraking vehicles; re-boost, guidance, navigation and control systems for orbiting vehicles; or which influence on orbit safety factors such as orbital debris and penetrating radiation.
Contact: Jeffrey Anderson (205) 544-1661

Land Surface/Atmospheric Interactions Related to the Hydrological Cycle —

Research activities undertaken will be in conjunction with interdisciplinary studies related to the Earth Observing System (EOS). Particular emphasis will be placed on interactions between unconsolidated sediments on the earth's surface and atmospheric processes in the boundary layer as affecting the hydrological cycle on a local and regional basis and all time scales. Mass and energy transport phenomena will be studied, as affected by surface topography; and roughness; soil type, packing characteristic moisture content, ground water table, as well as by air temperature and humidity, wind characteristics, cloud cover, precipitation (rainfall, snowfall) duration and intensity and aerodynamic forces; ground cover (vegetation, snow); surface and sub-surface rock formation. Comparison with available hydrologic models will be made for the conditions studied, in conjunction with appropriate atmospheric circulation models. The results of such comparisons will be verified by appropriate instruments/sensors from laboratory experimental investigations, field ground-based stations and remote sensors (truck borne, air borne and/or space borne). The same research activities may include theoretical/numerical studies to develop inverse-problem techniques to deduce subsurface ground conditions from surface data obtained by either ground-based or remote sensors.

Contact: N. Costes (205) 544-1637

Systems Analysis and Integration Laboratory

Engineering Graphics Workstation —

High-performance computer workstations are utilized to visualize and study spacecraft design and configuration. Development of innovative concepts focuses on utilizing workstations to perform trade studies and analyses to achieve optimal configuration and assembly sequences for projects such as the Space Station Freedom.

Contact: R. Harrison (205) 544-2455

Hubble Space Telescope System Requirements —

Flight verification and checkout operations of the HST are being conducted. A facility composed of hardware and special monitoring and analysis software has been developed to support initial operation to the HST directly. Another activity in this area is completion of the technical requirements for Advanced X-Ray Astrophysics Facility (AXAF).

Contact: J. Loose (205) 544-2422

Configuration Management — Configuration management is an essential component of any successful engineering activity. Marshall projects tend to be both large and complex, requiring the efforts of teams of both NASA and contractor engineers. The level of control required by manned space flight makes configuration management a critical activity. Automated tools and methods are improved approaches and continually sought. Contact: G. Throver (205) 544-2375

Systems and Components Test and

Simulation — Opportunities exist for the development, qualification, integration, and flight acceptance testing of space vehicles, payloads, and experiments. Neutral buoyancy

simulations for training and development of extra-vehicular activity (EVA) techniques are performed. Thermal vacuum testing is conducted in a variety of chambers with capabilities to 1×10^{-7} torr and temperature ranges from -300°F to $+400^{\circ}\text{F}$. Facilities exist to calibrate X-ray payloads and scientific instruments utilizing a 309-meter evacuated guide tube. Contact: V. Kulpa (205) 544-1383; R. Stephens (205) 544-1336 Environmental Testing; C. Reily (205) 544-1298

Missions Operations Laboratory

The Mission Operations Laboratory performs functions contributing to performing science in space, particularly focusing on development of space science operations capabilities. Supporting that development, the Laboratory operates the Huntsville Operations Support Center from which Spacelab science operations are controlled and the Payload Crew Training Complex in which flight crews are trained for on-orbit science activities. The operations control function includes command planning, ground control plans and procedures, requirement development for flight system design, and flight system operation. The data management function includes air-to-ground data flow analysis, requirement development for flight data systems, and intercenter data requirement development. The crew operations support function includes crew procedure development and flight data file development. The mission planning function includes orbit analysis, mission timing, flight design, and design and development of planning systems including artificial intelligence applications. The ground systems development and operation function includes facilities operation, communications and data systems development, and command and telemetry data base development. The training function includes flight crew training, ground operations personnel training and development of training systems. Contact: Brian E. Blair (205) 544-6796

**Safety, Reliability, Maintainability,
and Quality Assurance Office****Reliability Engineering**

Research and analysis are conducted to gain understanding of complex physics of failure mechanisms with the Space Shuttle Main Engine. The use of statistical models, failure mode and effects analysis, and analysis of failure and anomaly reports, as well as applicable generic data, contribute significantly toward the research efforts.

Contact: F. Safie (205) 544-5278

Quality Engineering

Research is performed in areas dealing with software quality control, nondestructive evaluation (radiography, ultrasonic, eddy current), critical process control, use and evaluation of inspection methods, and assessment of critical characteristics in inspection with respect to control of critical items.

Contact: R. Bledsoe
(205) 544-7406
R. Neuschaefer
(205) 544-7382

Systems Safety Engineering

Opportunities exist for research in the development and implementation of quantitative and qualitative techniques directed at the identification, evaluation, and control of hazards associated with complex space systems. This includes probabilistic risk assessment, fault tree analysis and applications, interactive hazard information tracking and closure systems, and the identification of conceptual approaches to establishing mission levels and requirements for various types of space missions.

Contact: J. Livingston (205) 544-0049

John C. Stennis Space Center

Program Administrator
Dr. Armond T. Joyce
Chief, Science Division
Mail Code HA10
Science and Technology
Laboratory
Stennis Space Center, MS
39529
(601) 688-3832

NASA's John C. Stennis Space Center, located near Bay St. Louis, MS, has grown into NASA's premier center for testing large rocket propulsion systems for the Space Shuttle and future generations of space vehicles. In addition to its reputation in rocket propulsion technology, the center has also developed into scientific community actively engaged in research and development programs involving space, oceans, and earth.

Stennis Space Center's primary mission is to support the development testing of large propulsion systems for the Space Shuttle, Advanced Launch System and the Advanced Solid Rocket Motor programs. Static testing is conducted on the same huge concrete and steel towers used from 1966 to 1970 to captive-fire all first and second stages of the Saturn V rocket used in the Apollo manned lunar landing and Skylab programs. Since 1975, the center has been responsible for flight acceptance testing on the Space Shuttle's main engines. The data accumulated from these ground tests, which simulate flight profiles, are analyzed to ensure that engine performance is acceptable and that the required thrust will be delivered in the critical ascent phase of Shuttle flights. No Shuttle main engine can fly before it is first tested at Stennis Space Center.

The Science and Technology Laboratory (STL), a multidisciplinary science and engineering organization, is the research arm of the Stennis Space Center. Remote sensing and image processing technology represents a significant portion of STL activities. This technology is brought to bear on earth and life science research. The same technology has been used at STL for developing systems for monitoring Shuttle launches, for rocket engine diagnostics, and for examining astronaut space suits. These research projects necessitate the development of appropriate information system technology. This research and technology development presents the following specific research opportunities.

Earth System Science — Research is oriented at using remotely sensed data to understand the state and dynamics of the earth with respect to natural and anthropogenic perturbations. Emphasis is given to research oriented to forest ecosystems and coastal ecosystems/

land:sea interfaces. Specific areas of research within the forest ecosystems research program include the dynamics and structure of tropical forests, forest vegetation stress, and energy exchange. Specific areas of research within the coastal ecosystems research program include methane emissions in wetlands, coastal geomorphic processes, productive capacity of wetlands, relationships between land use and phytoplankton in near-shore waters, and suspended sediment related to spatial and temporal dynamics of river plumes and shelf waters.

Life Sciences — Research into the use of vascular plants for waste treatment, air purification, and food production in sealed systems suitable for space habitation; systems for clean-up of toxic spills; development and integration of sensing and data analysis systems for environmental life support monitoring and control.

Commercialization — Promote commercial use of NASA-developed remote sensing technology through the efficient and cost-effective transfer of such technology; develop and consolidate the commercial user requirements of Space Station *Freedom* as a platform for Earth observations.

Sensor Systems — Design and development of a variety of remote sensing systems for visible, infrared, thermal, and microwave regions of the electromagnetic spectrum; development of sensor systems for airborne platforms and ground applications, including in-situ sensors linked to transmitting systems, for land and ocean remote sensing; development and proto-typing gas and leak detection systems, especially hydrogen; identification and quantification of cold leaks for rocket propellants.

System Analysis and Integration — Systems engineering, man/systems integration, monitoring systems for environmental life support for space habitation, logistics support analysis, configuration management techniques.

Propulsion — Develop spatial and spectral information analysis system for studies of combustion dynamics and engine diagnostics; use of fiber optic techniques for combining video and spectrometry for support operations on diffuser test stands; LOX/hydrocarbon fuel technology, cryogenics, metrology, cleaning techniques. LOX compatibility, and non-destructive test and evaluation instrumentation.

Information Systems/Computer Science — Information and data base management, simulation and modeling systems, visualization and computer graphics, spatial analysis, numerical analysis, software engineering tools and methods, networking, advanced system design and development of artificial intelligence/expert systems for interpretation and analysis of spectrometer signals of rocket exhaust.

Graduate Student Research — Students are encouraged to develop study programs that include thesis or dissertation research conducted in residence at the Stennis Space Center either totally or through some combination of time at Stennis Space Center and on-campus. However, it may also be possible to conduct research in conjunction with field activities associated with Science and Technology Laboratory projects. It is suggested that the student applicant contact a Science and Technology Laboratory researcher for discussion of the student's research interests prior to

preparing a proposal. The following persons can be contacted for the initial discussion of the student's interests.

Earth and Life Sciences

Contact: A.T. Joyce
(601) 688-3832

Information Systems/Computer Science

Contact: S.L. Whitley
(601) 688-3586

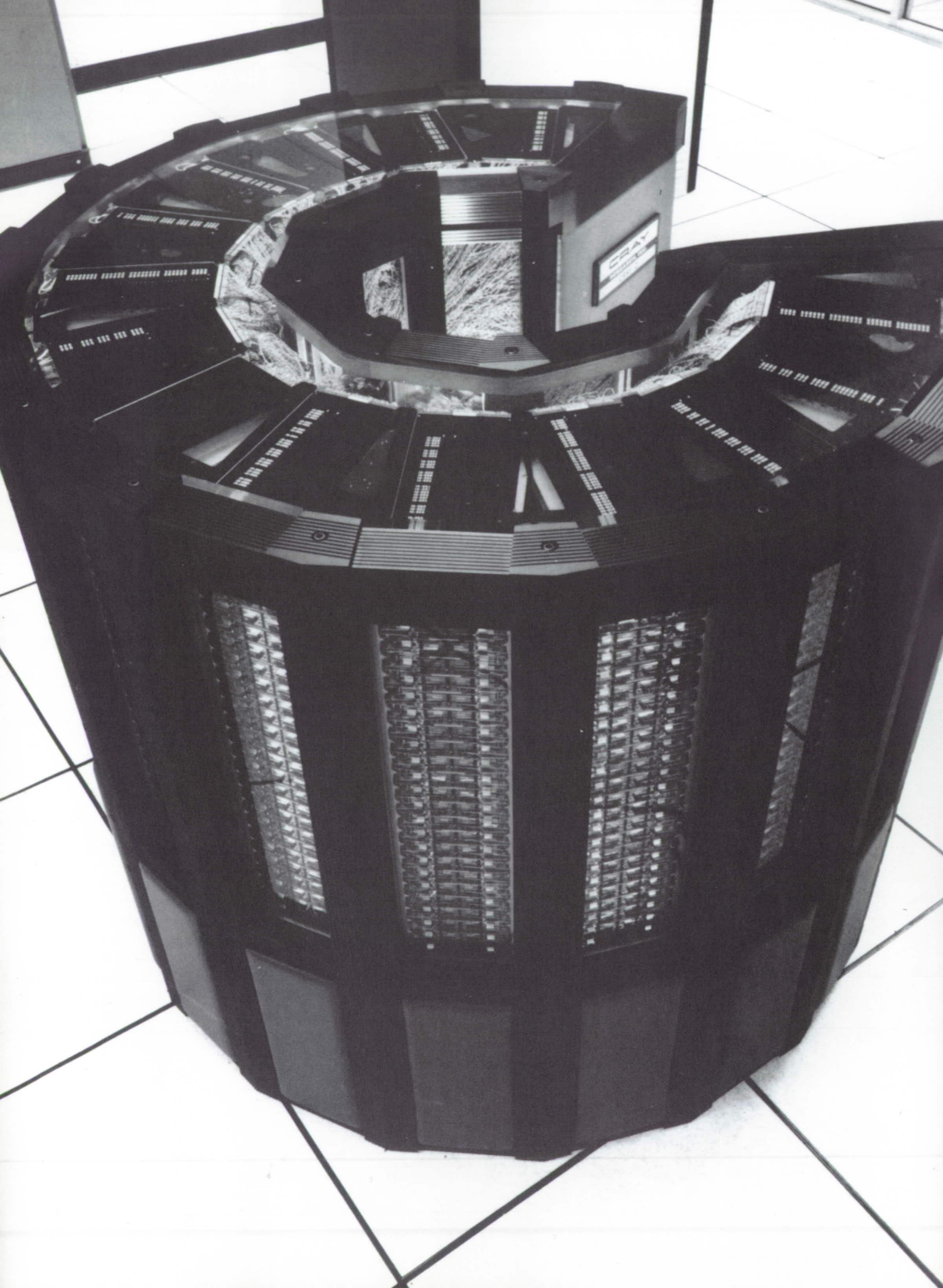
Commercial Programs

Contact: R.M. Barlow
(601) 688-2042

Engine Diagnostics and Sensor Systems

Contact: E.G. Woods
(601) 688-2777

*Section III —
Underrepresented
Minority Focus
Component*



Summary and Objectives

For more than 30 years NASA has had significant involvement with numerous universities across the nation. Talented faculty, graduate students, and postgraduates have carried out research for us. While we are pleased with these valuable relationships, we are concerned that relatively few members of underrepresented minority groups are participating in this research. Students selected for the program will collaborate with university investigators and with NASA technical officers at Headquarters or at one of the NASA field centers.

The program offers:

- up to \$22,000 per year of support for 3 years
- first hand exposure to NASA research
- the opportunity to work at national laboratories with unique facilities
- the chance to interact with the nation's top aerospace engineers and scientists.

Awards are initially made for a one year period and may be renewed annually.

Eligibility

Because Blacks, Hispanics, American Indians, and Pacific Islanders (having origins in any of the original peoples of Hawaii; the U.S. Pacific Territories of Guam, American Samoa, and the Northern Marianas; the U.S. Trust Territory of Palau; the Islands of Micronesia and Melanesia; and the Philippines) have been underrepresented in science and engineering, they are the focus of this special effort. Applicants must be

- sponsored by a principal investigator who is working on a current NASA research grant or cooperative agreement
- enrolled in a full-time graduate program at an accredited U.S. college or university
- studying engineering, physics, mathematics, computer science, biology, aeronautics, space sciences, life sciences, or another discipline of interest to NASA
- highly motivated to pursue their plans of study in NASA related research
- U.S. citizens

Students may enter the program at any time during their graduate work or may apply prior to receiving their baccalaureate degrees. An application must be sponsored by the student's graduate department chair or faculty advisor.. Those selected will usually receive support until they obtain an advanced degree, a maximum of three years in most cases. Individuals accepting this award may not concurrently hold another Federal fellowship or traineeship. Students who apply to this program are also eligible for the Graduate Student Researchers Program.

Selection of Proposals

Graduate students will be selected on the basis of their academic qualifications; the quality of their plan of study or proposed research and its relevance to NASA's research interests and needs; if applicable, the student's utilization of research facilities at the NASA centers; and to maintain appropriate balance between male and female applicants.

Application Procedure

Requests for funding under the program may be submitted after the grant to the principal investigator has been awarded.

Applicants should submit eight copies of the following application materials by February 1 of each year to the NASA facility which monitors the grant through which the student has been identified. Addresses are listed on page 103.

1. *Proposal Cover Sheet.* The form included in this publication must be filled out and attached to the proposal after being signed by the graduate student, principal investigator, graduate advisor, and the university contracting officer.

2. *Proposal.* The proposal must include:

A. **Student Statement:** A short summary prepared by the student of the student's educational training and accomplishments, transcripts showing grades, the objectives of graduate study, and how the program would address those objectives.

B. **Abstract:** A summary of the proposed research, objectives, and methodology.

C. **Proposed Research:** A statement that describes the key elements of the proposed research or plan of study. Detail the specific role the student will play and the availability of the principal investigator to work with the student. This section should not exceed two pages. *Center applicants should include a description of the NASA center facilities and resources the applicant wishes to use in support of the research, including an estimate of any computer time.*

D. **Schedule:** Schedule should include the proposed starting and ending dates, and if applicable, the approximate periods the student and faculty advisor expect to be at the NASA center to conduct activities. Start dates for new submissions can be no earlier than July 1. Students funded through Headquarters should plan to present research results at a three day symposium in the spring of each year in Washington, DC., to exchange ideas and discuss progress. Specific details regarding this conference will be communicated after awards have been made.

E. **Budget:** Twelve month budget should include the following items: (1) Student stipend: \$22,000 basic stipend for 12 months; (2) Student allowance:

\$3,000. Should include cost estimates of tuition expenses and/or anticipated travel and living expenses for the student at a NASA facility. (3) University allowance: \$3,000. Should include cost estimates for travel of faculty advisor to a NASA facility to coordinate and oversee the work of the graduate student, or to attend Washington symposium, as appropriate. If necessary, student tuition may also be charged against this allowance. The use of training grant funds for the purchase of nonexpendable equipment is prohibited. New applicants attending symposiums prior to their grant start date may be reimbursed for travel expenses.

Submission for Renewal

Proposals for renewal are to be submitted to the appropriate Program Administrator by February 1 of each year. Applicants should submit eight copies of all materials. The proposal for renewal should include student grades; an updated abstract describing progress made and anticipated progress to be made during a renewal period; budget, including the amount of unexpended funds anticipated at the ending date of the annual grant; as well as a written renewal recommendation from the principal investigator. Even though renewal proposals are required by February 1, the actual grant renewal start date will be 12 months from the original grant start date.

For Further Information

Contact: Program Manager,
Graduate Student Researchers Program, Code XEU,
NASA Headquarters, Washington, DC 20546.
Telephone: 202/453-8344; or contact the
appropriate official below:

- Mr. Samuel Miller
Mail Stop 241-3
Ames Research Center
Moffett Field, CA 94035
(415) 604-6585
- Dr. Gerald Soffen
Code 160
Goddard Space Flight Center
Greenbelt, MD 20771
(301) 286-9690
- Dr. Harry I. Ashkenas
Mail Stop 183-900
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-8251
- Dr. Stanley H. Goldstein
Mail Code AHU
Lyndon B. Johnson Space Center
Houston, TX 77058,
(713) 483-4724
- Mr. Dennis Armstrong
Mail Stop PM-TNG
Kennedy Space Center
Kennedy Space Center, FL 32899
(407) 867-2737
- Dr. Samuel E. Massenberg
Mail Stop 105-A
Langley Research Center
Hampton, VA 23665
(804) 864-4000
- Dr. Francis J. Montegani
Mail Stop 3-7
Lewis Research Center
21000 Brookpark Road,
Cleveland, OH 44135
(216) 433-2956
- Dr. Frank Six
Mail Stop DS01
George C. Marshall Space Flight Center
Huntsville, AL 35812
(205) 544-0997
- Dr. Armond Joyce
Mail Stop HA-10
John C. Stennis Space Center
Stennis Space Center, MS 39529
(601) 688-3830
- John T. Lynch
Code XEU
NASA Headquarters
Washington, D.C. 20546
(202) 453-8344



**Graduate Student Researchers Program
Underrepresented Minority Focus
Proposal Cover Sheet**

GRADUATE STUDENT

NAME (Last, first, middle)		<input type="checkbox"/> NEW SUBMISSION	<input type="checkbox"/> FIRST RENEWAL	<input type="checkbox"/> SECOND RENEWAL
HOME ADDRESS			PHONE (Include area code)	
NAME AND ADDRESS OF UNIVERSITY			PHONE (Include area code)	
TARGET DEGREE <input type="checkbox"/> MS <input type="checkbox"/> MS/PhD(joint) <input type="checkbox"/> PhD	EXPECTED COMPLETION DATE OF DEGREE		PROPOSED START OR RENEWAL DATE OF GRANT	
GRADUATE G.P.A. (If applicable) ____ OUT OF A POSSIBLE ____	GRADUATE DISCIPLINE	UNDERGRADUATE G.P.A. ____ OUT OF A POSSIBLE ____	UNDERGRADUATE DISCIPLINE	

I Certify that I am a citizen of the United States and am or will be a full time graduate student during the period covered by the attached proposal, and that I am a member of one of the following underrepresented minorities:

- | | | | |
|---------------------------------------|------------------------------------------|-------------------------------------------------|---------------------------------------------------|
| <input type="checkbox"/> BLACK MALE | <input type="checkbox"/> HISPANIC MALE | <input type="checkbox"/> AMERICAN INDIAN MALE | <input type="checkbox"/> PACIFIC ISLANDER* MALE |
| <input type="checkbox"/> BLACK FEMALE | <input type="checkbox"/> HISPANIC FEMALE | <input type="checkbox"/> AMERICAN INDIAN FEMALE | <input type="checkbox"/> PACIFIC ISLANDER* FEMALE |

*A person having origins in any of the original peoples of Hawaii; the U.S. Pacific Territories of Guam, American Samoa, and the Northern Marianas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; and the Philippines.

SIGNATURE	DATE
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PRINCIPAL INVESTIGATOR (Continued on other side)

NAME	PHONE (Include area code)
UNIVERSITY MAILING ADDRESS (Including building identification and room number)	
PROJECT TITLE	
NASA RESEARCH GRANT OR COOPERATIVE AGREEMENT NUMBER (Include name of NASA center)	FUNDING FOR EXISTING PROJECT IN FISCAL YEAR ____ AMOUNTS TO \$ THE PERIOD OF PERFORMANCE FOR THE EXISTING PROJECT ENDS DATE

Number of students supported by the existing project. (Place numbers in appropriate blocks.)

STUDENTS	NON MINORITY		BLACK		HISPANIC		AMERICAN INDIAN		PACIFIC ISLANDER		OTHER	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
UNDERGRADUATE												
GRADUATE												

Number of students utilized as research assistants or teaching assistants on NASA grants (Place numbers in appropriate blocks)

RESEARCH ASSISTANT												
TEACHING ASSISTANT												

APPROVALS

SIGNATURE OF PRINCIPAL INVESTIGATOR		DATE	
NAME AND TITLE OF GRADUATE ADVISOR	SIGNATURE	DATE	PHONE (Include area code)
NAME AND TITLE OF UNIVERSITY CONTRACTING OFFICER	SIGNATURE	DATE	PHONE (Include area code)

FOR NASA USE ONLY (Please do not write below this line)

NAME AND TITLE OF TECHNICAL OFFICER (Include name of NASA center)	SIGNATURE	DATE	PHONE (FTS No.)
-------------------------------------------------------------------	-----------	------	-----------------