FROM THE ARCHIVES

Resident Research Associateships, Postdoctoral and Senior Research Awards: 1997 Opportunities for Research Tenable at the United States Air Force Laboratories, Armstrong Laboratory, Phillips Laboratory, Rome Laboratory, Wright Laboratory (0)

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National Research Council

Resident Research Associateships

Postdoctoral and Senior Research Awards

1997

OPPORTUNITIES FOR RESEARCH

tenable at the

UNITED STATES AIR FORCE LABORATORIES

Armstrong Laboratory
Phillips Laboratory
Rome Laboratory
Wright Laboratory

administered by the
NATIONAL RESEARCH COUNCIL
Washington, DC

The National Research Council serves as an independent advisor to the federal government on scientific and technical questions of national importance. Established under the congressional charter of the private, nonprofit National Academy of Sciences, the Research Council brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees. Today the Research Council stands as the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering and is administered jointly by the two academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

The National Research Council has nine major divisions. One of these, the Office of Scientific and Engineering Personnel, is charged with administering Research Associateships through its Associateship Programs office.

Contents

Introduction

History and Objectives

The National Research Council conducts the Research Associateship Programs in cooperation with sponsoring federal laboratories and research organizations approved for participation.

The Research Council, through its Associateship Programs office, conducts a national competition to recommend and make awards to outstanding scientists and engineers at recent postdoctoral and experienced senior levels for tenure as guest researchers at participating laboratories. These Programs have been conducted on behalf of a number of federal agencies since 1954.

The objectives of the Programs are (1) to provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are compatible with the interests of the sponsoring laboratories and (2) to contribute thereby to the overall efforts of the federal laboratories.

For recent doctoral graduates, the Programs provide an opportunity for concentrated research in association with selected members of the permanent professional laboratory staff, often as a climax to formal career preparation.

For established scientists and engineers, the Programs afford an opportunity for research without the interruptions and distracting assignments of permanent career positions.

Participating laboratories receive a stimulus to their programs by the presence of bright, highly motivated, recent doctoral graduates and by senior investigators with established records of research productivity. New ideas, techniques, and approaches to problems contribute to the overall research climate of the laboratories. Indirectly, Associateships also make available to the broader scientific and engineering communities the excellent and often unique research facilities that exist in federal laboratories.

For the 1997 program year, an anticipated 1,300 applications will be received for the nearly 350 new awards to be made in the Associateship Programs.

Research Associateships at the United States Air Force (USAF) Laboratories

In the Research Associateship program sponsored by the United States Air Force (USAF) Laboratories, an Associate is a guest researcher, not an employee of the Research Council or of the laboratory. Associateships are analogous to fellowships or similar temporary programs at the postdoctoral level in universities and other organizations. They are not intended to be, or to compete with, permanent professional career positions.

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

Associates must devote their full-time effort to the research program proposed in their applications and must be in residence at the sponsoring laboratory during the entire period of the Associateship. No period of tenure may be spent in residence at another laboratory or institution. Associates have the status of visiting scientists or engineers but are subject to the general regulations of the laboratory.

No additional monetary aid or other remuneration may be accepted from another appointment, fellowship, or similar grant, except for sabbatical leave, during the period of the Associateship.

Postdoctoral or Senior Research Associate Status and Length of Tenure

Postdoctoral Research Associateships are awarded to persons who have held the doctorate less than five years (with preference for applicants having less than two years) at the time of application and are made initially for one year.

Senior Research Associateships are awarded only to applicants who have held the doctorate five years or more at the time of application. Senior Research Associateship applicants should be of the calibre of visiting fellows and have research experience that has resulted in significant contributions and recognition as internationally known experts in their specialized fields, as evidenced by numerous publications and professional society awards of international stature. Although awards to Senior Research Associates are usually for one year, awards for periods of three months or longer may be considered.

Under certain conditions, extensions may be granted to allow Associates to bring their research to a reasonable stage of completion. However, extensions are not automatically granted, and applicants are advised to plan their research programs to conform to the length of tenure stated above.

Consideration

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

Citizenship

Opportunities at USAF laboratories for Postdoctoral Research Associateships funded by the Air Force Office of Scientific Research are open only to US citizens and legal permanent residents. A few Postdoctoral Research Associateship opportunities may be open to non-US citizens in special cases where additional support is available from the laboratory.

Senior Research Associateships are open to a limited number of US and non-US citizens.

Although most opportunities at USAF laboratories are limited to unclassified research, all guest investigators, including Research Associates, are subject to USAF regulations governing visiting scientists.

Openings for non-US citizens are subject to USAF visit authorization procedures, which may delay or prevent an award. Prospective non-US applicants who are uncertain of their eligibility are advised to contact the Associateship Programs office before submitting a formal application. All applicants must have a full command of the English language.

Visa Requirements

Non-US nationals who are offered awards must have valid visas throughout tenure. Only Exchange Visitor and Immigrant Visas are acceptable to the Research Council. If an awardee chooses to apply for an Exchange Visitor Visa, sponsorship must be by the National Research Council. If he or she chooses to apply for an Immigrant Visa, the Research Council is not involved in the procedure.

Education and Experience

Awardees must hold the PhD, ScD, or other earned research doctoral degree recognized in US academic circles as equivalent to the PhD or must present acceptable evidence of having completed all the formal academic requirements for one of these degrees before tenure may begin. Applicants must have demonstrated superior ability for creative research.

An applicant's training and research experience may be in any appropriate discipline or combination of disciplines required for the proposed research.

Opportunities for Research

This booklet contains abstracts, or opportunities for research, that describe areas of research in which Associateships may be awarded at USAF laboratories.

The Air Force Office of Scientific Research provides the funds for this program, and the USAF laboratories furnish all necessary support services, facilities, and equipment for the approved research program of each Associate.

While every effort has been made by USAF to provide opportunities of ample scope and relevance, the publication of any opportunity in this booklet does not guarantee that it will be available at the time awards are offered. Changes and/or deletions may occur following publication because of temporary lack of equipment, laboratory renovation, staffing already sufficient to meet research goals, or a lack of funding.

Research Adviser and Laboratory Program Representatives

Shown with each opportunity for research is the name of a Research Adviser who conducts or directs the work described in the opportunity.

An Adviser is a USAF scientist or engineer with whom a Postdoctoral Research Associate works most closely. An Adviser acts as a surrogate of the Research Council in monitoring an Associate, and all matters relating to an Associate's research program fall under his or her purview.

For a Senior Research Associate, an Adviser functions in a more collegial relationship and assists as needed in securing technical support and resources.

The Laboratory Program Representative is a professional staff member at the USAF laboratory who is responsible for managing its Research Associateship program and for assisting an Associate with all administrative aspects of tenure:

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Research Proposal

Each applicant must submit a research proposal that relates to a specific opportunity for research at a USAF laboratory. A proposal must be the original work of an applicant and be approved by an Adviser listed with the opportunity.

Before writing a proposal, however, an applicant is advised to communicate directly with the Adviser, who can provide more specific information on current research and available technical facilities and offer scientific support of proposal development.

Laboratory/Center Review

Each applicant's proposal must be approved by one of the Advisers listed in this booklet and endorsed by the Program Committee at a USAF laboratory to be eligible for an award.

The endorsement affirms that the proposal is compatible with USAF's interests and that adequate programmatic support will be available if an award is offered.

USAF's action on the proposal, together with a copy of the Adviser's comments, will be provided directly to the applicant by the Program Representative.

No applicant will be eligible for further consideration until the Associateship Programs office has been advised by USAF that his or her proposal has been approved by an Adviser and endorsed by the Program Committee. Otherwise, the Associateship Programs office will assume that the proposal is not of sufficient current interest to USAF or that support facilities cannot be made available.

Since the final review of applications is conducted by special panels appointed by the Research Council, all applicants should note that endorsement by an Adviser or laboratory, while essential to the application process, does not imply or guarantee an award by the Research Council.

The Panel Review

The Associateship Programs office receives all application materials and supporting documents and conducts the competitive evaluations of applications.

Evaluations for USAF Associateships are conducted in February, June, and October by special panels convened for this purpose. Panelists are chosen to review applications on the basis of their stature and experience in the fields of science and engineering, and their evaluations become the basis from which awards are made on behalf of USAF.

Applicants are recommended for awards only after this open, national competition, in which the panels rank candidates on the basis of quality alone.

Final ranking in order of quality and the recommendation of applicants for awards are the exclusive prerogatives of the panels, and only notification by the Associateship Programs office of an applicant's status in the competition is authoritative.

Stipend

An Associate receives a stipend from the Research Council while carrying out his or her proposed research. The current annual stipend for a Postdoctoral Research Associate is $39,000 with additional increments for each year beyond the PhD. An appropriately higher stipend will be offered to Senior Research Associates.

This stipend is subject to adjustments from time to time in accordance with general national guidelines pertaining to scientists and engineers.

The Research Council is required by the US Tax Code to withhold an amount from the stipends of non-resident aliens who hold Exchange Visitor (J-1) Visas. Exchange Visitors are advised that approximately 30% per month will be withheld from stipends and reported to the US Internal Revenue Service annually.

Applicants are cautioned against entering into any agreement or understanding with individual Advisers or other laboratory personnel for additional funding or other remuneration for work as an Associate.

Stipends for Associates are limited to the amounts and by the conditions set forth above, and any other arrangement, formal or informal, between an applicant and laboratory personnel for additional monies or other considerations is strictly prohibited by the Research Council.

Initiation of Tenure

Sufficient time must be allowed between the offer of an award and the beginning of tenure to enable the Associateship Programs office and USAF to complete all necessary administrative procedures.

The date on which tenure may begin is negotiated on an individual basis, normally within six months of the award. The starting date may be delayed by mutual agreement of USAF, the Associate, and the Associateship Programs office but cannot be later than 12 months from the date on which the award was originally offered.

If this condition cannot be met, a new application, including a newly approved Research proposal, must be submitted to the Associateship Programs office and will be judged without prejudice in the next competition.

Visit Authorization Clearance

Associateship awards at USAF are subject to the issuance of a visit authorization clearance. Initiation of tenure will depend on the laboratory's obtaining a clearance for an Associate, and applicants are advised to consider the time required to process the clearance when planning the date on which tenure may begin. Specific details and procedures are available from the office of the Program Representative.

Prior Affiliation with the Laboratory

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

Prior affiliation includes direct employment relationships either with the laboratory or with a contractor whose work is performed there. A long-term consulting relationship usually makes an applicant ineligible.

Research contracts with universities that provide support for graduate students or faculty who perform research on campus are not ordinarily considered to be disqualifying.

Reapplication

Persons who have previously held an Associateship may apply for another award only if a period of at least two years will have elapsed between termination of the first award and the proposed tenure of a second.

Persons who have previously applied for an Associateship, but who were not recommended for an award by the panels, may reapply after one year.

Candidates who were recommended for an award by the panels, but who were not offered an award because of funding or other limitations, may reapply at any time without a mandatory waiting period.

Taxes and Insurance

As a guest investigator, an Associate is self-employed. All arrangements for payment of income taxes are the responsibility of the individual Associate, who is advised to become familiar with the relevant sections of the current tax codes.

The Research Council is required by the US Tax Code to withhold an amount from the stipends of non-resident aliens who hold Exchange Visitor (J-1) Visas. Exchange Visitors are advised that approximately 30% per month will be withheld from stipends and reported to the US Internal Revenue Service annually.

Job-related injury or death is covered by insurance (workmen's-compensation type). A group health-insurance program is required for Associates and is optional for dependents.

Relocation and Travel

A suitable relocation reimbursement will be determined for each awardee. Funds are also available for limited professional travel during tenure, provided such travel is approved in advance by the Associate's Adviser and the USAF Program Representative. Details will be provided at the time of the award.

Publication

Since an Associate's later scientific and technical career will be judged by others, publication in the accepted open technical literature is highly encouraged.

Publications should include a statement indicating that the research was conducted while the author held a National Research Council Research Associateship.

Application Procedure

Detailed information on procedures and all necessary application materials and supporting documents are available on request from the

Associateship Programs
TJ 2114
National Research Council
2101 Constitution Avenue NW
Washington, DC 20418

E-Mail: rap@nas.edu
WWW (Internet): http://www.nas.edu/rap
Gopher: nas.edu/rap

All deadlines for receipt of application materials are strictly observed by USAF and the Associateship Programs office. No allowances or exceptions are made for late submissions.

Application materials from previous competitions may not be used.

Panel Review Schedule

Although applications for USAF Research Associateships are accepted throughout the year, they are evaluated by the Associateship Programs panels only in February, June, and October.

February Review

To be eligible for review in February, completed application materials must be postmarked no later than January 15, 1997, and received by the Associateship Programs office no later than January 25, 1997. Supporting documents must be received by February 15, 1997.

June Review

To be eligible for review in June, completed application materials must be postmarked no later than April 15, 1997, and received by the Associateship Programs office no later than April 25, 1997. Supporting documents must be received by June 1, 1997.

October Review

To be eligible for review in October, completed application materials must be postmarked no later than August 15, 1997, and received by the Associateship Programs office no later than August 25, 1997. Supporting documents must be received by October 1, 1997.

Application Materials

Submit the following to the Associateship Programs office:

Signed Application
Questionnaire Sheet
Research Proposal (1 Copy)
Previous and Current Research

Supporting Documents

Have the following sent directly to the Associateship Programs office:

For Postdoctoral Research Associateship Applicants

Official transcripts of all graduate and undergraduate credits.

Four Reference Reports from the respondents listed on the Application. Only official Reference Reports may be used.

For Senior Research Associateship Applicants

Transcripts are not required of Senior Research Associateship applicants.

Letters of reference are accepted in lieu of Reference Reports. Senior Research Associateship applicants should endeavor to include some letters of reference from individuals who are not co-employees.

Laboratory/Center Documents

Submit the following directly to the Laboratory/Center Research Adviser:

Research Proposal (1 Copy)
Laboratory/Center Review (1 Set)

The Adviser will review the proposal and forward it to the Program Committee for review.

Notification of Awards

Awards are made only by the National Research Council. The endorsement of an application and research proposal by USAF, while essential to the application and review processes, does not constitute an agreement or obligation to confer an award.

A review board, drawn from members of the Research Council panels, determines a cutoff score. Applicants who score below this score cannot be considered further for an award and are so notified within two to four weeks.

Applicants who score above the cutoff score are recommended for awards by the board. These applicants are notified of the board's action as early as possible and are offered awards or alternate status to the extent of available facilities and funding by USAF.

Acceptances and declinations must be made directly to the Associateship Programs office of the National Research Council.

Opportunities for Research

ARMSTRONG LABORATORY
Brooks Air Force Base, Texas
Wright-Patterson Air Force Base, Ohio
Tyndall Air Force Base, Florida

The Armstrong Laboratory conducts basic and applied research and development in four multidisciplinary areas: the behavioral, physical, and physiological aspects of human performance and safety in military operations. The Human Resources Directorate develops personnel selection, classification, technical training, aircrew training, and logistics technologies. The Crew Systems Directorate develops personnel protection, emergency escape, life support, crew performance, and man-machine interface technologies. The Occupational and Environmental Health Directorate develops environmental exposure limits for hazardous chemicals, noise, and electromagnetic energy and provides environmental health and safety services for Air Force operations. The Aerospace Medicine Directorate develops medical-selection and -retention criteria and provides medical specialty services in preventive medicine, epidemiology, hyperbaric medicine, and drug-abuse prevention. The Environics Directorate develops technologies for site remediation and pollution control to comply with all regulatory laws and to minimize Air Force hazardous waste streams.

HUMAN RESOURCES DIRECTORATE
Brooks Air Force Base, Texas
Williams Gateway Airport; Mesa, Arizona

The Human Resources Directorate of the Armstrong Laboratory is the principal Air Force organization for planning and executing the Air Force's exploratory and advanced development programs in manpower and personnel, aircrew training, simulation, logistics, and technical training. Personnel research and development explore issues of selection, classification, assignment, evaluation, and retention of Air Force members and overall force structure and utilization. Research and development in aircrew training focuses on principles and technologies for developing and maintaining flying and combat skills using simulators and other training devices. Logistics studies include both management science and human factors, technologies for considering logistics factors at each step in the development and acquisition of systems, and productivity of maintenance personnel in operational environments. Technical training research includes developing principles and technologies for training design, delivery, and evaluation to improve the efficiency and effectiveness of training by considering content, sequence of instruction, and media.

The Aircrew Training Research Division, located at Williams Gateway Airport; Mesa, Arizona, is the Air Force's primary organization for research and development that supports aircrew training. The division's basic mission is to increase aircrew effectiveness through enhanced training techniques and technologies. The NRC Associate will take part in a behavioral sciences program that supports work into the salient perceptual and cognitive factors impacting flying training that permit aircrews to successfully function in the high stress and high workload domain of flight. Emphasis is placed on developing low-cost technologies that can be used to support combat training objectives.

Opportunities at the Aircrew Training Research Division are open only to Senior Associates.

Models of Pilot Aptitude, Learning, and Performance

WC Tirre 13.01.01.01

Brooks Air Force Base, Texas

We conduct basic research on the cognitive, perceptual, and psychomotor abilities that enable the acquisition, performance, and retention of flying skills. Research focuses on how models of cognition, perception, and performance might suggest new measures of individual differences parameters that could be used in pilot selection and classification, and on individual differences in situation awareness and how these relate to basic cognitive and perceptual processes. We use the Basic Flight Instruction Tutoring System (BFITS), which is a flight simulation and performance measurement system hosted on a 486 DX computer. It is designed for the flight-naive student, trains the declarative and procedural knowledge underlying basic flight maneuvers, and can be used to measure performance in skilled pilots. Research on situation awareness will be conducted with the Situation Awareness Flight Training and Evaluation System (SAFTES), which is now being developed. In addition to BFITS and SAFTES, we have an extensive collection of computer-administered cognitive, perceptual, and psychomotor ability tests developed by scientists in the Learning Abilities Measurement Program at Armstrong Laboratory. Scientists are supported by a technical staff of 10 programmers and analysts, and studies are conducted at a facility equipped with 40 486 DX and Pentium computers.

Cognitive Abilities

PC Kyllonen 13.01.01.02

Brooks Air Force Base, Texas

We conduct basic research on the nature of human intelligence, and all components of the human information processing system. Research is encouraged on working memory, declarative and procedural knowledge stores, learning ability, and information processing rate. Emphasis is placed on techniques for measuring these components using computerized tests; demonstrating how these components are the basic building blocks of complex learning and thinking; and exploring the relationship between basic components and the speed of learning new concepts and techniques, and the ability to apply those concepts on the job. We are also interested in noncognitive influences on information processing, such as mood and personality. Research is done in collaboration with psychologists throughout the world, at our experimental facility. This facility consists of over one hundred personal computers (20 Pentium machines; the remainder, 486 and 386 machines) that administer tasks to over 400 subjects per week (basic military trainees). There is a full programming staff and proctoring support to assist the Associates in developing computerized tasks and collecting data. Colleagues working on the project consist of five government scientists and a number of visiting scientists and support workers.

Student Modeling

VJ Shute 13.01.01.03

Brooks Air Force Base, Texas

The Training Research in Automated Instruction (TRAIN) project is a basic research program, jointly sponsored by the Air Force Office of Scientific Research and the Human Resources Directorate of the Armstrong Laboratory. Research facilities are equipped with 30 Compaq 486-33 computers to support more than 50,000 subject hours per year. TRAIN's mission is (1) to study effective pedagogical approaches to improve learning from computerized systems and (2) to develop innovative student modeling techniques to be employed within those systems. This opportunity focuses on the second research area (student modeling). As part of the program, we have recently developed a powerful and general student modeling paradigm called Student Modeling Approach for Responsive Tutoring (SMART). The premise is that a single, principled approach to student modeling, involving both theoretical and empirical methods, can render automated instruction more efficacious across a broad variety of instructional domains. SMART applies regression equations to learners' actions to predict knowledge and skill level, per curricular element. Research opportunities exist in the following areas: intelligent tutoring systems, cognitive/student modeling, curriculum and instruction, knowledge and skill acquisition, cognitive diagnosis, automated cognitive task analysis, and aptitude measurement.

Artificial Intelligence and Instruction

JW Regian 13.01.01.04

Brooks Air Force Base, Texas

The Artificial Intelligence and Instruction Program is an ongoing basic and applied research and development program sponsored by the Air Force Office of Scientific Research and the Human Resources Directorate of the Armstrong

Laboratory. The goal of this research is to develop a coordinated set of pedagogical principles to enhance instructional efficiency in the context of automated instructional systems. The evaluation laboratory contains 30 Compaq 486-33 microcomputers and assets to support more than 50,000 subject hours per year. The applied research component is more diverse, but works generally toward developing automated instructional systems in actual Air Force or educational domains. Research opportunities exist in the following areas: intelligent tutoring systems, cognitive modeling, curriculum and instruction, knowledge and skill acquisition, cognitive diagnosis, and aptitude measurement.

Intelligent Performance Support for Instructional Design

JM Spector 13.01.01.05

Brooks Air Force Base, Texas

The Intelligent Performance Support for Instructional Design is an ongoing exploratory research effort. Our overall goal is to develop and test tools and technologies which make instructional design expertise accessible to a wide variety of courseware developers in order to increase productivity of developers while improving courseware quality and effectiveness. We explore and elaborate the differences between novice and expert instructional designers, develop and test an integrated set of instructional design principles to guide specific types of courseware development, and analyze new instructional delivery technologies with regard to optimal instructional use. Research opportunities exist in the following areas: (1) case-based instructional design problem-solving, (2) cognitive modeling of the instructional design process, (3) computer-based instructional prescriptions, (4) evaluating automated instructional design tools, (5) guided elaborations for designing both structured and open learning environments, and (6) interface designs for courseware development tools.

Aircrew Training Research Division

Aircrew Training and Instruction Research

RA Thurman 13.01.11.01

Williams Gateway Airport, Arizona

THIS RESEARCH OPPORTUNITY IS OPEN ONLY TO SENIOR ASSOCIATES.

We conduct applied research and development activities that focus on the principles and technologies needed to acquire and sustain flying and combat skills. Our goals are to understand the psychological principles that are important to instruction and to develop programs that successfully integrate technology and training to support the acquisition of skilled performance in dynamic, complex environments. The Division maintains a variety of aircrew training devices including desktop simulations, part-task trainers, virtual environment simulations, and full mission simulators. These devices may be operated independently or linked to form collective synthetic training environments. The Division has a rich history of basic and applied research in aircrew training and seeks candidates to conduct field research in operational units. Research opportunities exist in the following areas: metrics and models of human performance, knowledge elicitation/cognitive engineering, knowledge and skill acquisition, information processing in high workload environments, decision making, learning and instruction, instructional simulation, computer-based training, virtual environment-based training, simulator-based training, curriculum and instruction, aircrew training, team training, and situation awareness.

CREW SYSTEMS DIRECTORATE
Brooks Air Force Base, Texas
Wright-Patterson Air Force Base, Ohio
Aberdeen Proving Ground, Maryland

The Crew Systems Directorate of the Armstrong Laboratory comprises four divisions located at two Air Force Bases and one Army Base: the Crew Technology Division, located at Brooks Air Force Base; the Human Engineering Division and the Biodynamics and Biocommunications Division, located at Wright-Patterson Air Force Base; and the Chemical and Biological Defense Division located at the US Army Edgewood Research, Development, and Engineering Center; Aberdeen Proving Ground, Maryland. The directorate conducts research and development in aerospace physiology and biotechnology, human performance, robotics telepresence, and protection against operational hazards including impact, sustained acceleration, vibration, rapid decompression, spatial disorientation, and disruption of circadian rhythms.

Human Performance

Human Performance under Sustained Acceleration

WB Albery 13.01.02.01

Wright-Patterson Air Force Base, Ohio

We conduct basic research on human perception and performance in the sustained acceleration environment, and on spatial orientation perception and human task performance in the simulated high G environment of aerial combat maneuvering. We are particularly interested in (1) techniques for measuring human task performance at high G in order to discriminate among various crew systems including G-protection ensembles, ejection seats, helmet mounted systems, and cockpit displays; and in (2) sustained acceleration on cognitive function. Research is conducted on the Dynamic Environment Simulator (DES), a 19-foot radius human centrifuge, which includes a wide angle visual simulation system in the DES gondola and several noninvasive physiological monitoring devices. Colleagues working on the centrifuge include five government scientists and ten support personnel.

Cognitive Psychophysiology

GF Wilson 13.01.02.02

Wright-Patterson Air Force Base, Ohio

The objective of this research is to use psychophysiological techniques to develop a better understanding of the relationships between cognition, performance, and physiology in complex task performance. Operator state is manipulated by varying task demands which effect mental workload, situational awareness, and performance. Laboratory, simulator, and flight environments are used to develop a data base and enhance our understanding of performance in complex environments. In order to understand the relationships between task demand and performance, we use multiple psychophysiological measures in conjunction with performance and subjective measures. This approach provides us with a multifaceted view of the complex relationship among the variables that impinge on the operator of complex Air Force Systems. Technology includes (1) facilities to collect 64 channels of EEG, cardiac, eye blink, and respiration data in laboratory and simulator settings; (2) eight and 32-channel ambulatory recorders for flight experiments; and (3) extensive laboratory-developed and commercial software for data reduction and analysis, including EEG topographic FFT and ERD analyses, heart rate, heart rate variability, eye blink, and respiration analyses. When appropriate, we augment these tools with other measures. We are developing the capability to use psychophysiological data on-line to predict operator state. Several classifier techniques are being examined to implement this approach, including neural networks, discriminant analysis, fuzzy logic, and hybrid approaches.

References

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Team Performance in Sustained Operations

SG Schiflett 13.01.03.01

Brooks Air Force Base, Texas

The objectives of this research are to acquire, develop, and apply methods for evaluating team performance and fitness for duty of individuals during extended, irregular, and nocturnal work periods. We evaluate the effects of selected chronobiological manipulations, biochemical aids, and work/rest schedules on cognitive performance and physiological status, in part to develop a computerized fatigue/performance model. Laboratory and operational field studies are conducted by interdisciplinary teams; the Aircrew Evaluation Sustained Operations Performance (AESOP) facility is the core of the laboratory. AESOP command-and-control workstations are designed for real-time acquisition of individual- and team-performance measures. A network of interconnected computers generate high-fidelity mission scenarios that place real-world task demands on distributed decision making of operators. Other facilities include a variety of cognitive and psychomotor performance-assessment systems and electrophysiological and biochemical laboratories.

Spatial Vision

MW Cannon 13.01.02.03

Wright-Patterson Air Force Base, Ohio

With the increasing use of remote sensing in military applications, bandwidth considerations for the transmission of visually interpreted sensor information will become critical. In the form of video images, infrared images, or synthetic aperture radar images, this information will require some form of bandwidth compression so that communication facilities are not overloaded. Since bandwidth compression schemes usually result in the loss of information, it is important to know what scheme is best for a particular task. We will focus on determining the information required for the detection and identification of targets in cluttered scenes. After determining the pertinent information, we will study the ability of the JPEG, Fractal, and Wavelet bandwidth compression schemes to transmit this critical information. These three schemes are the most popular candidates for efficient image coding. Our experimental approach will be based on the responses of spatial filters tuned to various spatial frequencies, orientations, and spatial locations, which comprise a model of the low-level processing in the human visual system. Using psychophysical experiments, we will study the computations performed on these filter outputs that determine either the presence of a target against a complex background (detection) or the similarity of a detected target to one of N stored prototype images (identification). Then, we will test the ability of these models to predict detection and identification when various bandwidth reduction coding schemes are applied to the target images. If these models prove successful, they can provide a useful tool for engineers designing displays or developing improved bandwidth compression schemes. Research opportunities exist to (1) design experiments to measure visual performance (psychophysical target detection and identification experiments) and (2) study basic visual modeling (define how the outputs of spatial filters are combined to yield target detection and identification performance similar to our psychophysical data).

Information and Complex Operator Control

R Warren 13.01.02.04
Wright-Patterson Air Force Base, Ohio

Many modern time-critical tasks and dangerous scenarios exceed the perceptual, cognitive, and performance capabilities of unaided humans. Such tasks include high-speed, low-altitude flight; general flight performance during high-stress, high-workload periods; naturalistic decision making; and the coordination and control of geographically distributed multi-operator efforts such as land and air battles. Because these scenarios are unavoidable, humans are increasingly using systems whose designs are driven by intuition and technological availability, rather than by empirical facts and a general theory of human information processing and action.

The objectives of this research are to (1) determine and describe the information necessary for a given task; (2) understand how information is used in the relevant cognitive process; (3) understand the nature of information distribution and sharing among amalgamated players; (4) develop data-based cognitive, decisional, and control aids; and (5) develop performance metrics for complex operator control.

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Auditory Perception and Speech Communication

TJ Moore 13.01.02.05
Wright-Patterson Air Force Base, Ohio

We conduct basic and applied research on auditory perception and speech communication. Auditory perception research focuses on the perception of real and synthetic auditory localization cues in simple and complex environments, as well as the interactions of the auditory and visual sensory systems. Research in speech communication involves both speech production and perception in stressed environments including noise, vibration, and acceleration. We are also using traditional signal processing and neural network assisted algorithms to study machine recognition of speech in benign and stressed environments. World class facilities for human auditory research include a large anechoic chamber that has a 14-foot diameter geodesic sphere with 277 loudspeakers, 3 large reverberation chambers with high intensity sound systems producing levels of up to 137 dB, computer assisted intelligibility and communication performance measurements, multiple Sun workstations and 386/486 PCs, and 6 additional acoustic research chambers. We collaborate with psychophysicists and engineers around the world. A capable hardware, software, and technical support staff is available to assist the fellow scientists and engineers in modifying and using the facilities for their research. In-house colleagues working on the project include 12 government scientists, a number of visiting scientists, and a support staff of approximately 12 members.

Circadian Neurobiology

MA Rea 13.01.03.02

Brooks Air Force Base, Texas

The Biological Rhythms and Integrative Neurosciences Research Group conducts basic research to elucidate the molecular and cellular mechanisms responsible for the generation and synchronization of circadian rhythms in mammals. Research concerns (1) the neurochemistry of photic entrainment of the circadian pacemaker located in the suprachiasmatic nuclei (SCN), (2) the cellular organization of the SCN circadian pacemaker, and (3) the characterization of clock-controlled and photically activated gene expression in the SCN. Techniques and approaches include neurochemistry, neurophysiology, molecular biology, immuno-cytochemistry, intracerebral microdialysis, tissue culture, neurotransplantation, telemetric recording of circadian rhythms in rodents, and intracerebral administration of neurotransmitter-specific drugs and antisense oligonucleotides targeted against neuropeptide and neurotransmitter receptor expression. Research facilities consist of 1800 square feet of laboratory space distributed between 5 adjacent rooms, and a dedicated 2000 square foot small animal facility including surgery, treatment room, and 2 animal rooms equipped to monitor circadian rhythms of 250 individually housed rodents. Computing facilities include a variety of Macintosh and Intel 486-based workstations with access by ethernet to high-resolution color and grey scale printers, a slide and transparency printing facility, and on-line services through Internet. A complete neurophysiology laboratory is available for studying the neurochemistry of spontaneous and electrically evoked neuronal activity in brain slices. A fully equipped tissue culture facility is available including laminar flow hood, autoclave, CO_2 incubators, cryostorage facility, and Olympus IMT2 inverted microscope equipped with epifluroescence and Namarski optics. The molecular biology laboratory includes Hoeffer electrophoresis and transfer equipment, DNA sequencing equipment, Perkin Elmer Gen Amp 9600 PCR system, ABI oligonucleotide synthesizer, and Molecular Dynamics Phosphor-Imager. Equipment for biochemical, neuroanatomical, and behavioral analyses includes a Spectronic 2000 scanning spectrophotometer; Perkin Elmer LS 5B scanning luminescence spectrometer; Waters high-performance liquid chromatograph with fluorometric, electrochemical, and photodiode array detection systems; a Beckman L5-50B ultracentrifuge; LKB 1470 gamma counter; LKB 1409 liquid scintillation system; Nikon and Olympus compound and dissecting microscopes; video-equipped Nikon Labophot 2 microscope with epifluroescence and dedicated image analysis system; and a Reichert Jung 2800 N cryostat. Investigators interact closely with colleagues at several universities and research institutes in the San Antonio area.

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Human Protection

Altitude Physiology

AA Pilmanis 13.01.04.01

Brooks Air Force Base, Texas

Aircrew and astronauts are exposed to the hazards of reduced ambient pressure and altered breathing gases. This research focuses on the physiological effects of exposure to high altitude and provides the physiological basis for developing protective countermeasures. Areas of interest include hypoxia, ebullism, positive pressure breathing, and decompression sickness (DCS). Our goals are to mathematically model decompression, including inert gas diffusion and perfusion dynamics, gas phase separation, bubble growth dynamics, and statistically based approaches; and to develop predictive DCS risk assessment capability. To validate such DCS models, we use an evolving DCS research data base derived from experimental human exposures to simulated altitudes in hypobaric chambers. *In vivo* intravascular gas emboli are detected by two-dimensional echocardiography and Doppler. We study predisposing factors such as oxygen prebreathing, exercise, and gender in order to predict the effectiveness of countermeasures. We also investigate ventilation/perfusion inequalities, peak pressures, and fluid shifts associated with high levels of positive pressure breathing, which is used at high altitudes to maintain arterial oxygen levels. Finally, we explore the pathophysiological mechanisms of tissue vaporization at extreme altitudes/hard vacuum (ebullism) in order to develop medical treatment protocols and protective countermeasures.

Biodynamics

I Kaleps 13.01.05.01

Wright-Patterson Air Force Base, Ohio

This research addresses basic and applied aspects of the interaction of mechanical energy with biological systems (man and animal). The mechanical environments of primary interest are vibration, impact, and changes in the sustained-force environment. The theoretical and experimental phases of this program include analyzing and modeling total human body and subsystem dynamic responses; developing data bases for anatomical, inertial, and material properties; and establishing performance decrement and injury tolerance criteria. Problems in this area pose challenges to scientists from various disciplines—mathematical, physical, engineering, physiological, psychological, and biomedical—and approaches vary from systematic experimental measurements to sophisticated mathematical and computer models. The laboratory has unique equipment to perform experimental and/or theoretical research in the areas described above: (1) a single axis and a six-degree-of-freedom vibration table, (2) a large gimbaled centrifuge, (3) horizontal and vertical deceleration devices, (4) a horizontal impulse accelerator, (5) computers for on-line processing of data and modeling of biological-system mechanical responses and functions, and (6) instrumentation for data collection.

Spatial Orientation

FH Previc 13.01.04.02

Brooks Air Force Base, Texas

The ability of humans to maintain spatial orientation in the abnormal acceleratory environment of flight is reduced relative to that on Earth. Spatial disorientation (SD) occurs when pilots experience illusions of aircraft position and motion, putting them at risk of losing control of their aircraft. Our research consists of three major efforts. (1) Through basic psychophysical research in the Visual Orientation Laboratory, and in motion-based and other simulators, we hope to understand the nature of spatial orientation. Therefore, we have emphasized the visual and vestibular mechanisms involved in maintaining orientation. (2) We are designing and evaluating new displays and symbology concepts in our Flight Instrument Development Laboratory (FIDL) that assist the pilot in maintaining spatial orientation in the aircraft. Both traditional (head-down and head-up) and nontraditional (helmet-mounted and acoustic) display symbologies and instruments have been or are being evaluated in the FIDL and our flight simulators, and during actual flight. (3) Visual-vestibular research in motion-based simulators supports the development of training protocols to expose pilots to realistic simulator-based SD illusions and scenarios, and to provide them with the skills necessary to prevent and/or recover from SD.

Man-Machine Integration

Human Alternative Sensory Feedback Telepresence

DW Repperger 13.01.06.01

Wright-Patterson Air Force Base, Ohio

Different modalities or alternative sensory feedback may be helpful in improving a human's telepresence in a remote or hazardous location. Our objective is to utilize information obtained from remote sensors located in the environment in conjunction with different types of feedback to the human in order to improve his understanding of the environment. Some feedback mechanisms promoting telepresence consist of force reflection, tactile stimulation, audio cuing, and virtual interfaces. Our research goals include (1) defining performance specifications and metrics to characterize manipulation of the human operator, (2) evaluating fidelity of current display and sensory modality feedback systems, (3) discerning between incompatible sensory modalities (sensory clutter) and those combinations of information that improve telepresence, and (4) coordinating the appropriate virtual reality visual display with the appropriate sensory feedback (force, tactile, audio). This project needs a multidisciplinary team, including people with mathematical, physiological, biomedical, and engineering backgrounds. Unique in-house capabilities exist to develop subsystem components for experiments that involve the above sensory modalities. Such components include force reflecting controllers, exoskeletons (with or without force reflection), visual, and extensive audio facilities.

Physics and Microbiology

BV Bronk 13.01.13.01

Aberdeen Proving Ground, Maryland

We have used micrometer-sized particles as "the world's smallest test tube"; therefore, we are interested in the physics, physical chemistry, and biology taking place within and on single micrometer-sized particles. Research involves (1) developing novel means to handle and suspend such particles (e.g., novel electrodynamic balances), and (2) studying theoretical and experimental methods to understand the signal which can be obtained from micrometer-sized particles using optical methods such as fluorescence, phosphorescence, elastic light scattering, and Raman scattering. Some applications consist of using the optical signal to identify the biological or chemical content of microparticles, as well as developing novel methods to determine the dynamics of single microparticles in real time. Since a major application focuses on applying the results of these investigations to detecting and identifying micro-organisms, we are also interested in antibody-antigen (AbAg) systems to sort and identify pathogenic organisms, and in methods which are potentially automatable for extracting recognition information from micro-organisms. Investigations may include the degree of specificity of the reactions, strength of the bond, and automation of handling of micron-sized beads attached to micro-organisms. Optical measurements of growth properties may also be used to reveal new experimental and theoretical aspects of bacterial growth.

OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
Brooks Air Force Base, Texas
Wright-Patterson Air Force Base, Ohio

The Occupational and Environmental Health Directorate conducts fundamental research and operational support missions. Research areas include the bioeffects of lasers and nonionizing radio-frequency radiation, applied statistical and mathematical modeling, and environmental toxicology. Operational support assesses the total operational environment from the human perspective by applying basic scientific, clinical-medical, public-health, and engineering principles. Both missions are accomplished by applying in-house contractual support. Research opportunities in toxicology are located at Wright-Patterson Air Force Base, and the remainder of the directorate is located at Brooks Air Force Base.

Toxicology

Environmental Toxicology

JW Fisher 13.01.07.01

Wright-Patterson Air Force Base, Ohio

The research objectives of this multidisciplinary approach to problems of aerospace toxicology are to (1) investigate the toxic potential of Air Force chemicals and atmospheric trace contaminants during intermittent and subchronic exposure, (2) explore basic mechanisms of chemical toxicity, and (3) develop toxicokinetic and toxicodynamic modeling approaches for use in toxicologic risk assessments. Investigations are also pursued to develop new analytical tools to measure metabolites in biological matrices. This program offers research opportunities for studies on mechanistic research in (1) the pathological evaluation of toxic injury at the cellular and subcellular levels, (2) computer simulation of toxicokinetic behavior of Air Force Chemicals, and (3) computer modeling of cytotoxicity and carcinogenicity. Postdoctural research opportunities exist in the fields of biochemical mechanisms of toxicity, toxicokinetics, pharmacodynamics, pathological evaluation, and analytical chemistry.

Directed Energy

Nonionizing Radiation Bioeffect Mechanisms

JL Kiel 13.01.08.01

Brooks Air Force Base, Texas

The goal of this research is to reveal physical, chemical, and cellular mechanisms of interaction between biological system and nonionizing (radio-frequency) radiation. Interactions of nonionizing radiation with other stressors such as ionizing radiation, laser radiation, chemical agents, and biological agents are also considered. The influence of radio-frequency radiation on oxidative and thiol metabolism, specific RNA transcription, protein translation, cell growth, and free-radical production are examined. Macrophage and lymphocyte functions, interactions, and responses are central to this work. The opportunity for developing biological redox systems to mineralize nitrates, nitrites, and possibly hydrazine using recombinant-DNA techniques is also available. We are also developing biological sensors to determine the hazards presented by the metabolic intermediates of these nitrogen compounds.

Applied Mathematics and Electromagnetic Wave Propagation

RS Albanese 13.01.08.02

Brooks Air Force Base, Texas

The Mathematical Products Division conducts a basic research program to understand the mathematical structures needed to predict the interaction of nonionizing electromagnetic radiation with biological media. Our primary goal is to produce accurate estimates of the absorbed energy a biological model would receive when located in proximity to an ultrashort pulse electromagnetic radiation source. The research approach applies analytical and computational mathematical methods to compute wave propagation in biological media for both linear and nonlinear dispersive regimes. We are also committed to the specification of electromagnetic inverse scattering algorithms with application to the noninvasive evaluation of internal dielectric structure in medical imaging and environmental settings.

AEROSPACE MEDICINE DIRECTORATE
Brooks Air Force Base, Texas

The Aerospace Medicine Directorate plans, manages, and conducts research in aircrew selection and retention, physical standards, medical aspects of force readiness and disease detection, surveillance, and prevention. Decision rules are derived and special tools created for evaluating low-prevalence diseases in health populations. Functional areas include long-term aircrew epidemiology, occupational modeling, clinical medicine, hyperbaric medicine, medical physiology, and preventive medicine.

Mathematical Cardiovascular Physiology

SWL Samn 13.01.09.01

Brooks Air Force Base, Texas

Sudden incapacitation in any form is unfortunate. For high-performance aircraft pilots maneuvering in a high +Gz environment it becomes more probable and can be disastrous. Compromised cardiovascular-system performance is believed to be a major contributing factor in incapacitation. This could be the result of some underlying, possibly even subclinical, disease processes that are exacerbated by high +Gz loading, or it may simply be a reflection of inherent human physiological limitations. Our current knowledge of cardiovascular physiology in high +Gz environment is relatively limited. The goal of this mathematical cardiovascular research is to achieve an understanding of cardiovascular performance in high +Gz environments by careful study of the basic mechanisms involved. Current interests include the mathematical modeling of electrophysiological phenomena in the heart (action-potential propagation in ischemic regions, for example) and hemodynamics (fluid mechanics of blood flow in the heart and in arteries).

Systemic Physiology

VA Convertino 13.01.09.02

Brooks Air Force Base, Texas

Investigations conducted in the Physiology Research Branch focus on elucidating basic physiological mechanisms in aerospace environments which provide a clinical basis for developing and applying the most effective procedures to protect or prevent aircrew from exposure to risk factors that may compromise their health, safety, and performance in Air Force Systems. By integrating our activities with those of other branches in the Clinical Sciences Division, we will advance our basic knowledge, understanding, education, and training in aerospace medicine and physiology; improve aircrew health maintenance and risk factor identification/intervention; and enhance "Force" fitness for optimum performance and physiological readiness for combat. We conduct experiments using both human and nonhuman primates to demonstrate the potential physiological risks to combat performance associated with physical inactivity and lack of G-training. These investigations enable us to predict adverse physiological conditions on aircrew performance during aerial combat maneuvers. Emphasis is placed on developing specific types of physical exercise to enhance aircrew fitness in order to ensure combat readiness on short notice. We analyze these data to predict health and fitness requirements for successful combat task performance in aerospace environments and to provide a basis for developing procedures (countermeasures) to minimize the risk of mission failure.

Research Methods in Occupational Epidemiology

JE Michalek 13.01.09.03

Brooks Air Force Base, Texas

Research focuses on conducting a 20-year prospective study of veterans of Operation Ranch Hand, the unit responsible for the aerial spraying of herbicides in Vietnam from 1961 to 1971, and a matched cohort of Air Force personnel who flew and serviced C-130 cargo aircraft in Southeast Asia during the same period and were not exposed to herbicides. Our goal is to determine whether exposure to herbicides, including Agent Orange and their contaminant, 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin), has adversely affected the health, survival, or reproductive outcome of Ranch Hand Veterans. Since 1987, dioxin exposure has been determined using serum measurements conducted by the Centers for Disease Control and Prevention. Research involves developing methods to assess morbidity and mortality with regard to exposure in cohort studies and estimating first order elimination rates with adjustment for covariates.

ENVIRONICS DIRECTORATE
Tyndall Air Force Base, Florida

The Environics Directorate conducts basic, exploratory, and applied research in two main research areas: site remediation and environmental compliance. Site remediation research focuses on providing new cost-effective technologies for cleaning up sites that have been identified with unacceptable levels of soil and/or groundwater contamination, principally from fuels and solvents. Research subtopics include *in situ* and *ex situ* bioremediation technologies, chemical treatments, and physical methods. In conjunction with remediation/treatment research, contaminant fate and transport processes are studied and developed using laboratory, field, and numerical methods. Site characterization and monitoring systems are being developed to assess remediation technologies and to validate predictive capabilities.

The second area, environmental compliance, focuses on technologies to measure and minimize air emission pollutants and waste streams. Research topics include hazardous waste minimization, air pollution control, and atmospheric fate and transport.

Biodegradation of Environmental Contaminants

J Spain 13.01.10.01

Tyndall Air Force Base, Florida

Research is conducted to discover and examine biological systems that degrade hazardous chemicals. Emphasis is placed on biodegradation of substituted aromatic compounds by bacteria. Basic research on pathways, strain construction, molecular biology, and ecology are complemented by applied research on scale-up and bioreactor development.

References

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Groundwater Solute Fate and Transport Research

TB Stauffer 13.01.10.02

Tyndall Air Force Base, Florida

Research focuses on the environmental fate and transport of chemicals, with special emphasis placed on groundwater fate and transport. Current research areas include processes which control the fate and movement of compounds such as sorption, sorption kinetics, redox chemistry, abiotic and biotic degradation, geochemistry, and mathematical modeling of flow and transport. Opportunities exist to conduct bench-level experiments through field-scale experiments to determine which processes are scalable. Excellent equipment and laboratory support are also available.

Abiotic and Biochemical Subsurface Contaminant Fate and Remediation

DR Burris 13.01.10.03

Tyndall Air Force Base, Florida

Research is conducted on abiotic and biochemical processes relating to the fate and degradation of contaminants in subsurface environments. Emphasis is placed on processes which may be used in the remediation of fuels- and/or solvents-contaminated groundwater. Current efforts focus on the degradation of chlorinated solvents mediated by dehalogenase enzymes, vitamin B_{12}, and zero-valent metals. Our goals are to integrate the disciplines of environmental chemistry, biochemistry, and environmental engineering to (1) improve our understanding of contaminant fate in the subsurface and to (2) develop innovative approaches to groundwater remediation.

Analytical Chemistry Research

HT Mayfield 13.01.10.04

Tyndall Air Force Base, Florida

Opportunities exist to conduct research in several areas of analytical chemistry, including mass spectrometry, chemometrics, and sample preparation/extraction techniques. Mass spectrometry opportunities consist of research in liquid chromatography, mass spectrometry, or supercritical fluid chromatography/mass spectrometry. These studies can involve method and hardware development, or theoretical research. Chemometric opportunities include method development and validation, and theoretical research. These projects can also include application of chemometric techniques to analytical data obtained from gas chromatography, mass spectrometry, and other instrumental sources. Research can be conducted to develop and test new techniques for environmental sample preparation and extraction. Basic developments in all of these areas can be applied to real-world environmental and microbiological samples.

WRIGHT LABORATORY
Wright-Patterson Air Force Base, Ohio

The Wright Laboratory is the principal Air Force organization for planning and executing aerospace vehicle research and exploratory and advanced development programs. In this role, Wright is the Air Force's lead laboratory in all science and technology areas that relate to materials and processing, electronic devices, offensive and defensive avionics, aero propulsion and power, cockpit displays and decision aids, aerospace vehicles, signature control, conventional armament, and manufacturing.

With 3,000 professionals working together as an integrated team to ensure that the Air Force continues to be a viable guardian of our national security, Wright manages an in-house research program that constantly challenges the outer limits of current research and routinely initiates contractual partnerships to tap into the expertise within industry, academia, state and local government, and private-sector business to implement the following:

— Discover enabling technologies that offer potential for revolutionary improvements in performance, affordability, and supportability of Air Force weapon systems;

— Develop and demonstrate advanced technologies for present and future Air Force weapon systems to best meet user needs and requirements;

— Guide the transfer of proven advanced technologies to weapon-system builders and users for timely incorporation by our fighting forces; and

— Solve pressing technical problems through aggressive, rapid-response support for any Air Force organization including Special Program Offices, Air Logistics Centers, and Operational Commands.

Wright's focus is on quality leadership and aerospace technology to assure the future. Our challenge is to provide the Air Force's combat component the revolutionary technological improvements that will give them the decisive winning edge in crisis situations.

AERO PROPULSION AND POWER DIRECTORATE
Wright-Patterson Air Force Base, Ohio

The Aero Propulsion and Power Directorate develops air-breathing propulsion and power technology needed for future Air Force systems, assists the product divisions to acquire new systems, and aids in resolving development and operational problems.

Extensive facilities are available for research in airbreathing propulsion and power. These include (1) a satellite computer for turbine engine control and general engineering computation; (2) a turbine-component heat-transfer facility to investigate cooling of turbine blades; (3) a totally automated, computer-controlled, sea-level engine test facility for full-scale lubricant development engine testing; (4) two sea-level turbine-engine test stands with up to 15,000-lb thrust capability and a propulsion aerothermodynamic research facility; (5) a sea-level engine test stand with a 60,000-lb thrust capability; and (6) a single-stage 2,000-hp compressor test facility including open- and closed-loop operation. A Compressor Research Facility, which independently evaluates full-scale, multistage, and single-spool fans and compressors under conditions similar to actual flight profiles, supports efforts in compressor technology. Three test stands are used to determine propeller performance under various accelerations and speeds, and a helicopter rotor facility is used to determine rotor performance under various accelerations and speeds.

The ramjet/scramjet test facilities permit the investigation of aerothermochemistry of high-speed combustion devices at simulated high altitudes. Available facilities consist of a large-scale and a small-scale direct connect thrust stand; a water tunnel to investigate combustion dynamics, mixing, and instabilities through transient and steady-state flow visualization, and residence time measurements in the recirculating regions of the flow; a water-cooled coaxial dump combustor designed and instrumented to accept a full complement of laser-diagnostic and conventional flow-measurement systems to provide fundamental and essential information for assessing turbulent transport models and computational-fluid-dynamics codes. A separate laboratory/test facility is available for combustion studies in supersonic flow regimes. This high-Reynolds-number test facility is designed to operate at flow velocities up to three time the speed of sound and is equipped with the latest technology in laser-based nonintrusive diagnostics for simultaneous field measurements of velocity, temperature, and species concentration. A fuel-injection and spray-technology tunnel is available for characterizing liquid fuel sprays. Laser diagnostics such as a phase-Doppler particle sizer and a Malvern instrument are used to complement high-speed photography and cinematography for studying the two-phase fluid phenomena.

A battery laboratory is available for basic research in electrochemical power generation. This facility contains automatic life-cycling equipment; instruments for electrochemical analysis and gas chromatography; an inert atmosphere chamber; a flame spectrophotometer; a scanning electron microscope coupled to a dispersive x-ray chemical analyzer; and a chemical laboratory. A thermal laboratory is used to conduct basic and applied heat-transfer research that is applicable to aerospace vehicle power-system thermal management. The facility supports research in heat-pipe performance, thermal-energy storage, high-speed rotating equipment cooling, and transient heat-transfer experiments related to pulse-power applications and high- and low-temperature diagnostics. A thermionics laboratory is operational for non-nuclear testing of thermionic energy-conversion devices. A superconductivity research laboratory is used to measure the physical and metallurgical properties of superconductive materials, and a high-power laboratory supports electrical power-component and system development by testing capacitive, inductive, and plasma energy-storage switching networks. Power-generation electrical equipment is evaluated in a laboratory that has three computer-controlled, 350-hp drive stands for aircraft-generator evaluation and data acquisition; the laboratory also houses conventional electronic test equipment to evaluate advanced solid-state power-conversion components. A plasma physics laboratory houses research on low-energy plasmas that have applications to lasers, high-power switches, and plasma processing of thin films, and an optical diagnostics laboratory performs research to develop techniques to explore combustion and plasma environments.

A fuels research facility permits the investigation of fuel lubricity and rheology; fuel-storage and heat-sink characteristics; and fuel-heat transfer using a variety of thermal stability, reactor, and heat-exchanger devices. Also included are combustion facilities for fundamental and applied combustion studies. The performance and parameters of new lubricants under typical engine conditions and the causes and effects of lubricant degradation are determined in lubrication-research facilities.

Airbreathing Propulsion

Ramjet Propulsion

AS Nejad 13.02.01.01

Wright-Patterson Air Force Base, Ohio

We conduct research on ramjet/scramjet and mixed-cycle propulsion components that are applicable to supersonic and hypersonic flight regimes. This includes fluid-dynamic studies involving inlet and nozzle components modeling of combustion processes, development of turbulence models for flows with recirculation, chemical kinetic studies, and internal heat transfer involving ablation processes. The work requires experimental and theoretical approaches to the following topics: (1) turbulent transport, entrainment, and mixing of multistream flows and/or two-phase flows including fuel injection, atomization, droplet transport and evaporation, flame stabilization, and blowout limits; (2) developing diagnostic instrumentation and concepts, including hardware and software, for applications to realistic combustor flow environments; and (3) developing time-averaged and time-dependent computational-fluid-dynamics codes for flow and combustion simulations in complex geometries. Available equipment includes extensive computer facilities (minicomputers up to CRAY class), a well-instrumented water tunnel with hot-water-injection capability, two combustor thrust rigs, a research combustor designed for a wide range of operations and applications of laser diagnostics, and a spray tunnel facility with associated optical and conventional diagnostic equipment. Also available is a stand-alone supersonic combustion-research facility, specifically designed for nonintrusive probing of the supersonic flowfield for simultaneous field measurements of pressure, temperature, velocity, and species concentration.

Combustion and Spray Studies and Diagnostic Development

JR Gord 13.02.01.02

Wright-Patterson Air Force Base, Ohio

This research addresses the physics and chemistry of processes in gas turbine combustors through the study of isolated and interacting droplets, sprays, jet premixed and diffusion flames, swirling flames, and bluff-body stabilized flames. Continuing work requires experimental and theoretical approaches related to the following: (1) turbulent transport, mixing, entrainment, evaporation, droplet drag, drop-spacing effects, atomization, finite-rate chemistry, flame stability, ignition, and blow-out; (2) development of laser diagnostic techniques to support combustion and spray experiments; and (3) studies using either time-averaged or large-scale, time-dependent simulations. Five well-equipped laboratories contain small- and large-scale combustion tunnels and advanced laser apparatus designed for two-dimensional imaging, coherent anti-Stokes Raman spectroscopy; laser Doppler anemometry; phase Doppler particle sizing; laser-induced florescence techniques; and femto/picosecond chemical kinetics studies. Access to a CRAY supercomputer and combustion flow codes are available for theoretical studies.

Model Development and Validation Experiments for Aircraft Fuel

JT Edwards 13.02.01.03

Wright-Patterson Air Force Base, Ohio

Aviation fuels are not only the energy source for advanced aircraft; they are also used to cool airframe and engine components. Under high thermal loads, hydrocarbon fuels can react with dissolved oxygen or undergo pyrolysis to form gums and other deposits that reduce the efficiency of heat exchangers and cause fouling of fuel-system components. Computer models that can be used to estimate the thermal decomposition of hydrocarbon fuels in simple heat exchangers are in an early stage of development. The models are time dependent and include global chemistry, fluid mechanics, and thermodynamic effects. Many of the fundamental processes associated with thermal degradation of fuel are not well understood. One of the objectives of the models is to improve our understanding of selected issues in physics and chemistry. Of particular interest is experimental and theoretical research on the influence of dissolved oxygen content, turbulence, thermal loads, pressure, catalytic reactions, or heat-exchanger geometry on the thermal degradation of hydrocarbons found in jet fuels. Dedicated minicomputers, a CRAY supercomputer, and reacting flow codes are available for theoretical studies.

Advanced Turbine Engine Lubrication

TA Jackson 13.02.01.04

Wright-Patterson Air Force Base, Ohio

This research focuses on developing advanced liquid, vapor, and solid lubricants and related mechanical components (bearings, gears, and seals) required for turbine engines to power aircraft in the twenty-first century. We are developing novel lubrication systems to minimize the weight and complexity of such systems employing advanced concepts, designs, and materials. Continuing research addresses thermal-oxidative degradation; and tribological, toxicological, and environmental properties of candidate lubricous materials. World class laboratory facilities equipped with unique test equipment and instrumentation are available for analytical, degradation, tribological, simulation, bearing and gear rig, load carrying, rolling contact fatigue, elastrohydrodynamic film, high-pressure viscometric, and diagnostic studies, Dedicated minicomputers and tribological modeling software are available for theoretical studies.

Aero and Thermodynamics of Rotating Machinery

RB Rivir 13.02.01.05

Wright-Patterson Air Force Base, Ohio

A greatly improved understanding of internal flows is necessary to the continued advance of turbine-engine performance. Advances will not come easily, for these flows exhibit effects of compressibility, viscosity, centrifugal forces, unsteadiness, heat transfer, and three dimensionality. The main thrust of this work would be to bring our newest analytical and experimental methods to bear on those phenomena that most impede progress: effects of curvature, pressure gradients, roughness, and unsteady flows; the behavior of secondary flows, three-dimensional shock systems, tip flows and heat transfer, nonlinear fluid-structure interactions; turbine losses, airfoil separation, and re-attachment with and without shock interactions. Also included is the prediction of turbine heat transfer for flows with large values of free-stream turbulence and the behavior of internal and external coolant flows. Analytical and experimental facilities exist to explore these issues related to improving turbomachinery performance.

Fluid Mechanics of Turbomachinery

WW Copenhaver 13.02.01.06

Wright-Patterson Air Force Base, Ohio

Turbomachinery fluid mechanics embody a complex set of unsteady interactions between aerodynamic phenomena. Flow fields are unsteady, three dimensional, supersonic, and greatly influenced by centrifugal acceleration. Transonic compressor tip region and endwall flow field management is critical to improvements in pressure rise, efficiency, and flow range. Therefore, fundamental knowledge of the complex flows within transonic compressors is essential to achieving maximum performance. One goal of this work would be to use our newest analytical and experimental methods to study the effects of tip vortices, endwall boundary layers, shock/boundary layer interactions, and tip clearance flows in turbomachinery. We must account for the presence of unsteady effects inherent in turbomachinery flows, identify the relative importance of length and time scales of unsteady flow phenomena, and provide for future improvements in turbomachinery technology based on the recognition of unsteady phenomena.

Along with the tightly packaged high-performance components, nonlinear fluid mechanics combine to produce dynamic structural loads in turbomachinery not predicted by design systems resulting in high cycle fatigue failures. The unsteady blade loads induced by unsteady flow phenomena dominate structural design requirements. Three areas must be investigated: (1) flow defects which incite the structural responses, (2) unsteady blade loads which result from complex interaction between fluid and structures, and (3) blade response which may lead to component failure. Flow defects that exist within turbomachinery components are highly unsteady and made up of wakes, potential disturbances, inlet distortion, shocks, and passage vortices. We have not systematically examined the roles and relative importance of viscosity, turbulence modeling, and nonlinearity. Application of advanced computational methods combined with controlled experiments must be compared with linearized theory to establish the level of approximation allowed for an accurate determination of blade surface unsteady pressures and to establish the sensitivity of the problem to those approximations.

The Compressor Aero Research Laboratory has unique analytical and experimental facilities for exploring issues related to improving turbomachinery performance. This laboratory contains a 2000 horsepower compressor test facility, measurement capabilities, high-speed graphics workstations, and advanced computational platforms.

Aero Propulsion Systems

Nonaqueous Liquid and Solid Polymer Electrolyte Studies

LG Scanlon, Jr 13.02.02.01

Wright-Patterson Air Force Base, Ohio

Recent developments in electrochemical devices (e.g., high-energy density primary and secondary lithium batteries) have generated considerable interest in nonaqueous liquid and solid polymer electrolytes. At this time, we do not completely understand the factors important for discharge/charge interfacial reactions, cycle life, electrolyte stability, and temperature dependence of conductivity. Our goals are to (1) determine factors important for electrode/electrolyte interfacial stability and ionic conductivity as a function of temperature, (2) maximize cation transport number, and (3) investigate the electrochemical kinetics in these electrolyte systems, using electrochemical techniques and modeling electrochemical problems. We are especially interested in investigating high-energy density and long life-cycle lithium batteries, lithium anode electrolyte interfacial stability, and high-temperature cathodes for thermal batteries. Instrumentation includes a direct-current plasma spectrometer, Fourier-transform infrared spectrometer, EG&G electrochemical analyzer, time-lapse video microscope, thermal-cell tester, thermogravimetric analyzer, differential scanning calorimeter with associated inert chambers, a 2% relative-humidity dry room, and modern computational equipment. An applicant should have a thorough working knowledge and hands-on experience of modern electrochemical techniques as they are applied to electrochemical power sources (batteries).

Applied and High-Temperature Superconductivity

CE Oberly 13.02.02.02

Wright-Patterson Air Force Base, Ohio

Opportunities exist to study new high-temperature superconductors, such as the copper oxide Perovskites. We use extensive magnetic property characterization equipment, including a variable temperature transport current apparatus capable of providing 2,000 A and 12 T, a vibrating sample magnetometer, an AC susceptometer, and a SQUID system for sensitive magnetization measurements. An opportunity is also available to manufacture and evaluate superconducting materials for a wide range of applied devices, and to establish a working relationship with industrial contractors who are developing large-scale superconducting power generation and pulsed power devices. We devise and test novel conductor configurations to minimize transient magnetic field losses. Critical to this research is an understanding of losses that result from transient magnetic fields for short-conductor samples and small models of high-power devices, such as pulsed-energy storage magnets, generator magnets, and rotating electrical generators. Transient heat transfer, normal zone propagation, and quench protection analyses are also important.

Physics of Electric Discharges

CA DeJoseph, Jr 13.02.02.03

Wright-Patterson Air Force Base, Ohio

Low-pressure, electrically excited gas discharges are studied in a number of configurations that involve direct current, radio frequency, and microwave excitation. Experimental and theoretical research includes excitation processes, energy transfer processes under nonequilibrium conditions, and electron transport. Applications for these studies are discharges used for thin-film deposition and etching. These films include those used in the semiconductor industry, which are wear resistant and have protective coatings. Experimental facilities include high-resolution Fourier-transform optical and mass spectrometers, quadrupole mass spectrometers, drift tubes for electron transport studies, flowing afterglow facilities, and systems for microwave deposition of diamond films and low-energy ionic deposition of large area diamond-like-carbon films. As part of the experimental facilities, a full-time glass blower is also available. Ongoing theoretical studies include discharge modeling and recovery of cross section information from electron transport data.

Applied Atomic and Molecular Spectroscopy

BN Ganguly 13.02.02.04

Wright-Patterson Air Force Base, Ohio

Spectroscopic methods are developed and applied for quantitative measurements in nonequilibrium plasmas and high-temperature reacting flows. Well-defined low to medium pressure discharges using direct current, low frequency to radio frequency, and microwave excitations are investigated for their application to thin-film deposition, plasma enhanced etching, surface modifications, and dielectric breakdown. Experimental and theoretical studies are being conducted to characterize homogeneous and heterogenous processes in plasmas and combustors including plasma-surface interactions and the creation and influence of self-ordered nanoparticles in plasmas. Rydberg state Stark spectroscopy, one- and two-photon allowed laser-induced fluorescence, static and dynamic light scattering, and photo absorption measurements are conducted using tunable ultraviolet to near-infrared laser sources. Experimental results are supported by theoretical modeling of electron kinetics and heavy particle interactions in nonequilibrium plasmas. We are currently developing a cascade arc source for low-cost surface coating application and a large area atmospheric pressure e-beam initiated discharge device for studies of high-pressure transient discharge phenomena.

Thermophysics and High-Temperature Dielectric Materials for Aerospace Secondary Power Systems

JE Beam 13.02.02.05

Wright-Patterson Air Force Base, Ohio

Heat transport, storage, and rejection represent fundamental limitations for future high-power, high-energy missions and for high-performance electric aircraft. Basic and applied heat-transfer and thermodynamic phenomena are examined analytically and experimentally with emphasis on their adaptation to secondary power-systems and thermal electronic management. Specific areas of interest include two-phase concurrent and countercurrent heat-transfer devices; capillary and other augmented heat-transfer methods for both low- and high-"g" applications; novel thermophysical and heat-transfer phenomena characterization; high- and low-temperature heat-transfer fluid-properties verification; unsteady heat transfer in pulsed and transient-phase change processes, with particular interest in rotating and cryogenic environments; and analysis and verification of direct and indirect liquid cooling for electronic component temperature control, and the solution of the conjugate problem associated with this configuration for silicon carbide applications.

In addition to thermal management of active devices, we are interested in capacitive storage devices. Capacitors are a critical component in nearly every military and commercial system today. Developing superior high-temperature, high-power capacitors begins with novel/innovative dielectric and electrode research. Therefore, our goals are to understand the electrical, thermal, and mechanical properties of high-performance (-55°C to >300°C) dielectric materials and to understand the influence of thermal and physical aging, and frequency variations on these properties. Emphasis is placed on understanding the dielectric microstructure and its effect on such macroscopic properties as dielectric constant, voltage breakdown strength, and dissipation factor. We also encourage molecular modeling of an amenable and promising dielectric material using a new numerical analysis to more fully understand these micro/macro relationships. Excellent material analysis, development, and electrical characterization facilities exist to support model development. As a secondary goal, the resulting model should be generic to a broad class of dielectric materials.

Computational Modeling for High-Speed Propulsion

B Sekar 13.02.02.06
Wright-Patterson Air Force Base, Ohio

Computational Fluid Dynamics (CFD) is becoming a powerful tool in the design and analysis of advanced airbreathing propulsion systems. As a result of improvements in numerical algorithms, geometric modeling, numerical discretization, grid generation, physical parameter modeling, and adaptability in the super computing environment (including parallel architecture), CFD tools can be applied throughout the development process. As a leader in the area, Wright Laboratory's Propulsion Systems Branch conducts research in interdisciplinary areas for high-speed flows. These areas include CFD, phenomenological physical modeling for turbulence for more accurate near wall physics, reduced reaction kinetics for hydrocarbon fuels, acceleration schemes to improve numerics including solution adaptive techniques, and unstructured grid technology. Research will emphasize analytical, computational, and numerical developments including appropriate model validations. Excellent computational platforms and high-speed graphic workstations are also available. This research will lead to an enhanced capability to design and analyze hydrocarbon fueled dual mode ramjet/scramjet engines.

AVIONICS DIRECTORATE
Wright-Patterson Air Force Base, Ohio

The Avionics Directorate is responsible for the research, exploratory development, and advanced development of avionics/electronics for aerospace vehicles. The directorate is developing avionics architectures and technology capable of leveraging rapidly evolving commercial technology while developing unique avionics systems/devices for those military requirements where commercial technology is not available. The directorate has a strong research program in radio frequency (RF) systems; electro-optical systems; combat information management (including automatic target recognition and information fusion); unique electronic device development (especially semiconductor device development); and simulation, modeling, and digital backbone development for aerospace systems. The directorate has numerous world class facilities to accomplish this unique mission. Some of these facilities include computer-aided design/semiconductor device fabrication facilities, model based vision (automatic target recognition) and sensor fusion facilities, electro-optical sensor/countermeasure development facilities, antenna and RF receiver research facilities, and modeling/simulation facilities. A wide range of expert researchers from government, industry, and university communities work together on site, across the US, and in some cases around the world, on funded efforts to develop the next generation of avionics for aerospace vehicles. The Avionics Directorate also has extensive collaborative interaction with researchers across the US and around the world to meet the avionics challenge. In most cases, applicants coming to the directorate will become very familiar with the worldwide research community in their technical areas.

The Avionics Directorate has pioneered research and development in synthetic aperture radar; laser radar; model based vision based (automatic target recognition); sensor fusion; reinforcement learning; microwave and infrared countermeasures; open architecture; multifunction avionics systems; reinforcement learning; optical phased array technology; very high speed integrated circuits; microwave/millimeter-wave integrated circuits; RF transmit/receiver modules; digital radio frequency receiver modules; A/D converters; and combined microwave, optical, and digital electronic functions on a single chip.

Machine Intelligence

AH Klopf 13.02.03.01

Wright-Patterson Air Force Base, Ohio

This research emphasizes adaptive behavior, reinforcement learning, and control theoretic models of nervous system function, as approaches to transitioning the mechanisms of natural intelligence to machine intelligence. We focus on learning mechanisms and hierarchical network architectures, which will yield robust forms of machine intelligence, in conjunction with arrays of sensors and effectors. Typical investigations involve synthesizing learning system designs (realized in software or hardware) that are tested by using on-line, real-time, closed-loop, goal-seeking interactions between the learning system and its environment. Relevant applications include dynamic control problems requiring learning, trainable automatic pattern recognition systems, and high-level decision-making systems. Available computational resources consist of MacIntosh IICXs and Quadras, Sun workstations, VAX Station 3s, and a Cray XMP.

Machine Perception and Physics-Based Object Recognition

LA Tamburino 13.02.03.02

Wright-Patterson Air Force Base, Ohio

The object of the machine perception program is to develop advanced processing systems based on adaptive learning and evolutionary computations. We explore automatic techniques to synthesize complex feature detectors and pattern recognizers for signal and image processing. We investigate performance-driven evolutionary discovery algorithms that grow and optimize processing networks. We also conduct image processing experiments with mathematical morphology. Research focuses on analyzing the high-resolution radar classification problem.

The physics-based object recognition program focuses on developing automatic target recognition (ATR) algorithms that are motivated by knowledge of target energy backscatter or emission, and the image and/or signal formation process. Particular emphasis is placed on physics-based ATR approaches to high-range resolution and synthetic aperture radar, broadband and multispectral infrared, and laser radar sensors. Fusion of these sensors for ATR is also of interest. An extensive data base of target signatures using all of the above sensors is available to support this research, as well as integrated KHOROS-based algorithm development software environment.

Extensive processing facilities are available, including parallel computers, Unix workstations, and high-performance PCs. For more information, see the model-based vision laboratory www page at http://www.mbvlab.wpafb.af.mil/.

Digital Microwave Receivers

JBY Tsui 13.02.03.03

Wright-Patterson Air Force Base, Ohio

Our goal is to build wide and narrow band receivers by digitizing the radio frequency (RF) signals. The wide band systems are for electronic warfare applications (EW), and the narrow band systems are for communication applications. Recent research on narrow band receivers has concentrated on (1) building a global positioning system receiver through software programming and digital signal processing, and (2) building a "software" radio in which the RF signal is digitized followed by all subsequent receiver circuits represented by real-time software. Recent research on wide band systems concentrates on (1) building a simple digital EW receiver to process two simultaneous signals, (2) using digital signal processing to improve EW receiver performance (i.e., sensitivity and dynamic range), and (3) using digital signal processing to measure angle of arrival and frequency.

Active/Passive Optical Sensor Research

PF McManamon 13.02.03.04

Wright-Patterson Air Force Base, Ohio

Our research focuses on the following:

(1) *Laser radar, especially tunable laser radar over the eyesafe wavelengths from 1.4 um to about 5 um.* Both coherent and direct detection laser radars are being considered. One objective is to identify objects based on the spectral reflectance measured by a tunable laser radar. We will investigate the phenomenology for target recognition at various source linewidths, as well as multispectral laser radar development. In the longer view, ultrashort laser pulses may also be considered as a method of sampling another dimension (the temporal dimension) to increase object recognition probabilities.

(2) *Laser radar receiver technology, including pre-amplifiers and avalanche detectors.* These approaches are considered for affordable, but highly sensitive direct and coherent detection receivers.

(3) *Optical phased array technology for steering active and passive electro-optical (EO) systems with little or no mechanical motion.* We are

working on both liquid crystal and micromechanical mirror-based approaches of implementing optical phased array concepts.

(4) *Passive infrared sensors, with emphasis placed on spatial sampling issues and multispectral target detection.* We investigate microscanning, especially random microscanning, as a method of increasing sampling and reducing aliasing effects.

(5) *Multifunction EO systems, including active and passive object detection and recognition, as well as digital and analog interconnects between sensor modules.* Ideally, we will move toward a single integrated EO system consisting of multiple aperture modules interconnected with a systems module. The distributed system will be capable of detecting and identifying objects in the air and on the ground, laser communications, laser designating, and countermeasures against threatening electro-optical systems. The multifunction system should be affordable, have no significant moving parts, be highly sensitive, have a high probability of object detection and recognition, and have a minimum reduction of capability as a result of atmospheric effects or contaminants.

III–V Devices and Integrated Circuits

FL Schuermeyer 13.02.03.05

Wright-Patterson Air Force Base, Ohio

Our work in semiconductor devices and integrated circuits for digital and analog applications focuses on the III–V heterostructure technology. The tasks include conventional GaAs/AlGaAs structures and advanced pseudomorphic structures based on In-, P-, and Sb-containing compounds. Work centers on HFETs (including complementary HFETs), HBTs, and resonant tunneling devices. We encourage submission of proposals in these areas, as well as other quantum phenomenon devices. The effort consists of both experimental and theoretical tasks. Experimentally, we grow the heterostructure layers on substrates such as GaAs and InP and then fabricate test devices and circuits in these materials. The device structures are characterized electrically and optically for parameter extraction and to understand the device's capabilities. Theoretical work includes device and/or material modeling, circuit simulation, and circuit design and layout. Our objective is to advance integrated-circuit technologies for dual-use functions such as high-speed processing for Air Force electronic warfare systems and for commercial applications.

Molecular-Beam-Epitaxial Crystal Growth and Characterization

CW Litton 13.02.03.06

Wright-Patterson Air Force Base, Ohio

Molecular beam epitaxy (MBE) of both doped and undoped III–V semiconductors, using Varian MBE 360 and Gen II Ultra-High Vacuum systems, has been conducted in the laboratory since late 1977. The objective of this research program is twofold: (1) to improve the electrical and optical quality of MBE GaAs and related III–V ternary and quaternary materials for digital microwave and optoelectronic-device applications and (2) to grow and characterize multilayer structures (superlattices) such as AlGaAs/GaAs, AlInAs/InGaAs, and antimony-based materials for possible device applications. Systems capable of growing n-type GaAs MBE layers on semi-insulating substrates with peak electron mobilities as high as 215,000 cm^2/V sec at 50 K and carrier concentrations as low as $1 \times 10^{14}/cm^3$. *In situ* characterization includes reflection electron diffraction and desorption mass spectroscopy, supplemented by photoluminescence, photoreflectance, infrared spectoscopy, Hall-transport, C/V profiling, DLTS, and x-ray diffraction. Opportunities exist to synthesize and characterize thin multilayer superlattice structures to seek a better understanding of the basic physics of 2 DEG conduction, tunneling, quantum-well effects, band bending at interfaces, and impurity trapping. An opportunity also exists to epitaxially grow and study the properties of wide bandgap III-nitride materials, GaN, AeN, and InN; their alloys; and heterostructures. Emphasis will be placed on studying and identifying native point defects and associated electron (hole) traps that are believed to control the electrical and optical properties of these materials.

III–V Molecular-Beam Epitaxy

KR Evans 13.02.03.07

Wright-Patterson Air Force Base, Ohio

Three molecular-beam epitaxy (MBE) systems are used to produce structures based on III-arsenides, III-antimonides, and III-nitrides, and many of their associated alloys. Current research falls into four categories:

(1) *Fundamental studies of the physics and chemistry of heterostructure growth.* We have documented the kinetics of cation and anion incorporation (including surface segregation effects and exchange reactions) during growth of several different III–V compounds and their interfaces (including GaN, A1GaAs, InGaAs, and GaAsSb).

(2) *Development of advanced in situ sensor-based monitoring and control technologies.* We have pioneered the development of desorption mass spectrometry for advanced process monitoring and real-time control of alloy composition.

(3) *Development of advanced MBE components.* We have developed a translatable source oven for continuous variation of incident group III flux.

(4) *Growth of heterostructures for materials studies, and for advanced electronic and optoelectronic device applications.* We support a range of activities including device efforts for lasers, HBTs, PHEMTs, infrared detectors, fundamental material studies of GaN, and low-temperature GaAs and InGaAs. We are also interested in low-dimensional structures such as quantum wires and quantum dots, and computer modeling of growth.

Solid-State Laser Source Development

KL Schepler 13.02.03.08

Wright-Patterson Air Force Base, Ohio

We study new laser materials that have a potential for high lasing efficiency and wavelength tunability. Research ranges from conception and exploratory research of new solid-state laser media to feasibility demonstrations of breadboard lasers using new materials. Areas of interest include spectroscopy of transition-metal laser materials, energy-transfer kinetics of mid-infrared rare-earth lasers, and nonlinear frequency conversion. Facilities are available to perform spectroscopic measurements of absorption, excited-state absorption, fluorescence, and fluorescence lifetime, and lasing-performance assessments of new materials.

Optical Studies of Compound Semiconductors and Their Heterostructures

DC Reynolds 13.02.03.09

Wright-Patterson Air Force Base, Ohio

We use several optical-characterization techniques—high-resolution photoluminescence (PL), selective-excitation, resonant-excitation, time-resolved spectroscopy, and modulation spectroscopies—to study the electronic properties of III–V semiconductors and their heterostructures. We investigate the behavior of shallow and deep impurities and excitations in epitaxial and multilayer structures, both in the absence and the presence of external perturbations. The high-resolution PL setup, which has both electronic and photographic recording capabilities, ranks as one of the highest-resolution facilities in the world. A pulsed capability has been added to the high-resolution PL apparatus. Although we focus primarily on the study of GaAs and AlGaAs properties and their heterostructures, we also investigate other systems such as InGaAs/GaAs. Wide bandgap materials such as GaN, InGaN, and AlGaN are currently being investigated.

Physics of Heterojunction Structures and Devices

CI Huang 13.02.03.10

Wright-Patterson Air Force Base, Ohio

We study the basic physics of microwave, microelectronics, and electro-optic devices that may lead to future millimeter-wave frequency and/or high-temperature monolithic integrated circuit applications. Both theoretical and experimental aspects of device research are of interest. Topics include one-/two-dimensional electron phenomena, tunneling, quantum-well effects, band bending at interfaces, unipolar/bipolar carrier transport, frequency/ temperature limitations (including failure mechanisms) of various devices, and device characterization. Device technologies that will facilitate these investigations are also being pursued. This research is an integrated part of a concerted effort in device/circuit development. Major resources include multilayer molecular beam epitaxial III–V structures, semiconductor characterization techniques and equipment, supercomputers, electron-beam lithographic machine/process, complete clean-room device-fabrication facilities, and DC/RF characterization instrumentation.

Solid-State Microwave Devices and Integrated Circuits

L Liou 13.02.03.11

Wright-Patterson Air Force Base, Ohio

We study the microwave device and integrated circuit both theoretically and experimentally, with emphases on heterojunction devices such as AlGaAs/GaAs, InGaP/GaAs, and InP-based Heterojunction Bipolar Transistors (HBTs) for monolithic millimeter integrated circuit applications. It is generally believed that the device performance is limited by the electronic properties of the device material. However, extrinsic effects such as thermal and parasitic often set a lower limit. We have demonstrated a "thermal shunt/thermal lens" technique to relieve thermal limitation, and have achieved a record high rf power output density from an AlGaAs/GaAs HBT. Work is in progress to further improve the device microwave performance. Our objective are (1) to understand basic device physics such as charge transport in the semiconductor devices and its relationship to practical microwave circuit characteristics such as frequency limitations, efficiency, linearity, noise, and the device failure mechanism through device, circuit modeling, and device characterization, and (2) to explore theoretically and verify experimentally novel device concepts and device process techniques for performance improvements including device reliability. Our major resource includes a device fabrication class 100 clean-room facility, dc/rf characterization instrumentation, e-beam lithographic machine, various computer-aided design tools including circuit layout design and circuit simulator, molecular beam epitaxial III–V crystal growth, and semiconductor characterization facilities.

Semiconductor Lasers-Physics and Technology

JP Loehr 13.02.03.12

Wright-Patterson Air Force Base, Ohio

Research focuses on optoelectronic devices, especially semiconductor lasers. The laboratory has a strong program in the modeling, design, growth, fabrication, and testing of both vertical and horizontal cavity lasers, and encourages applicants in all of these areas. Particular topics of interest include (1) microcavity effects in semiconductor lasers; (2) mode structure, dynamic response, and temperature dependence of laser structures; (3) full-band quantum transport calculations that include carrier scattering and quantum-well capture; and (4) ultrafast spectroscopy and nonlinear optics. The laboratory provides a fully equipped class-100 clean room, e-beam lithography, molecular-beam epitaxy growth equipment, high-speed computer facilities, and a variety of material and device characterization instruments.

FLIGHT DYNAMICS DIRECTORATE
Wright-Patterson Air Force Base, Ohio

The Flight Dynamics Directorate is the responsible to the Air Force for the technologies of aeromechanics, flight control, cockpits, structures, and equipment/subsystems for aircraft and aerospace vehicles.

This Directorate also integrates technology across Wright Laboratory, and is the lead laboratory for flight testing. Among the Directorate's current scientific and technical interests are (1) hypervelocity vehicles, supported by the technology advances in propulsion, computational fluid dynamics, and high-temperature structures; (2) short takeoff and landing and short takeoff/vertical landing, supported by the technology advances of low-speed aerodynamics, lightweight structures, autonomous landing guidance, and propulsion; (3) fighter-battle management, supported by the technology advances of three-dimensional displays for crew stations, voice enhancement, rapidly reconfigurable cockpits, reconfigurable microprocessors, and crew/vehicle integration; and (4) reliability/ maintainability and supportability, supported by the technology advances of fault-tolerant flight control, fracture mechanics applied to electronics, artificial intelligence, aircraft battle-damage repair, robotics, cryocoolers, and windshield transparencies. An important element of the Directorate's research capability is its abundance of experimental facilities. These include wind and water tunnels, structural tests, dynamic tests, landing gear, tires, flight-control simulators, and survivability research facilities.

Smart Structures for Aerospace Vehicles

GP Sendeckyj 13.02.07.01

Wright-Patterson Air Force Base, Ohio

A fundamental understanding of the effect of embedded sensors and actuators on the structural response of host composite materials is necessary to successfully develop smart aerospace structures. Development of the necessary basic understanding has created the following research opportunities: (1) modeling the structural response of composites with embedded sensors and actuators; (2) development of finite element analysis methods for materials exhibiting piezoelectric, bi-elastic, and magnetostrictive behavior; and (3) developing damage detection approaches using embedded sensors.

Mathematical Optimization in Multidisciplinary Design

V Venkayya 13.02.07.02

Wright-Patterson Air Force Base, Ohio

The basic objective of multidisciplinary design is to integrate the various disciplines that constitute the environment of a flight vehicle. The goal of modern design is to optimize the total system rather than the individual components, permitting the conflicting requirements of the subsystems to be handled much more effectively in getting optimal solutions. Design is a huge optimization problem consisting of libraries of variables, constraints, and performance functions. By expanding and contracting these libraries, we can explore the inherent coupling between subsystems and the disciplines. This understanding is also critical for efficient design integration. Topics of interest include (1) simultaneous design with multiple constraints; (2) structural requirements derived from strength, stiffness, and frequency considerations; (3) static and dynamic aeroelastic requirements; (4) requirements from a thermal environment; (5) linear and nonlinear aerodynamic interactions with the structure and control system; (6) survivability and vulnerability considerations; (7) tailoring of composites and other new materials; (8) development and testing of efficient optimization methods; and (9) analytical and automatic differentiation methods for gradient information.

Computational Electromagnetics and Acoustics

JJS Shang 13.02.07.03

Wright-Patterson Air Force Base, Ohio

An opportunity exists for basic research in computational electromagnetics and acoustics to support the DOD High-Performance Computing Modernization Program. The goal is to create efficient and scalable numerical simulation capability using time-dependent Maxwell and Navier–Stokes equations for electromagnetic and acoustic phenomena.

In the tiered-structured approach to computational electromagnetics and acoustics environment, our research focuses on developing the numerical methods for three-dimensional Maxwell equations in the time domain and time-dependent Navier–Stokes equations. For refraction, diffraction, and long-range wave propagating dominant phenomena, the high numerical resolution algorithm development and its validation in three-dimensional applications is one of the critical, leading elements. The basic criterion for numerical algorithm selection is to minimize numerical errors in dissipation, dispersion, anisotropic, and aliasing when applied to multidimensional problems. Innovative ideas in compact differencing, optimizing scheme, and other approaches are highly encouraged.

The other element of this research opportunity involves the concurrent computing discipline for gaining greater numerical efficiency. In this area, research can center on porting developed numerical procedures onto massively parallel computers through the unique domain decomposition technique, or creating novel scalable numerical algorithms. All path-finding research efforts are intended to fully integrate into all pertaining scientific disciplines, and harness them for a seamless air vehicle technology and spinoff potential.

Multivariable Control Systems

SS Banda 13.02.07.04

Wright-Patterson Air Force Base, Ohio

Research focuses on the areas of reconfigurable flight control, robust flight control, tailless fighter control, and uninhabited air vehicle control. Specific problems of interest include (1) real-time system identification and on-line control design algorithms; (2) on-line strategies to account for control saturation for reconfigurable controls; (3) innovative gain scheduling techniques; (4) robustness of nonlinear control design techniques; (5) algorithms to optimally allocate control power over a suite of nonlinear, coupled effectors; and (6) formation flight control of uninhabited air vehicles. Our goal is to develop and validate control algorithms through real-time, nonlinear simulation.

Integrated Optimum Design of Flight Vehicles

NS Khot 13.02.07.05

Wright-Patterson Air Force Base, Ohio

Integrating a design process by simultaneously considering the requirements of different design aspects is necessary to achieve optimum performance of future aerospace vehicles. The traditional approach of designing a vehicle has been to sequentially satisfy the requirements of each discipline—material selection, structural geometry, or control system. There are many fundamental issues that require investigation for a better understanding of the integration process and its consequences. Topics for this research include (1) efficient optimization algorithms for multiple objective functions and multiple constraints, (2) evaluation of sensitivities over a broad range of disciplines, (3) optimum design of smart structures using piezoelectric ceramics and shape memory alloys, (4) use of parallel processors for integrated-design approaches, and (5) use of genetic algorithms and neural networks in design.

Nonclassical Materials, Structures, and Stability of Aircraft Subsystems

AH Mayer 13.02.07.06

Wright-Patterson Air Force Base, Ohio

The purpose of this research is to remove the performance limitations on flight-vehicle subsystems or develop knowledge to understand and control them. The subsystems of greatest interest are (1) aircraft landing gear, tires, wheels, and brakes; (2) the aircraft windshields and canopies; and (3) armor and ballistic survivability.

Our research is predicated on the policy that basic science is essential to advancements in subsystems. Examples of subsystems problems awaiting definite formulation and investigation include the development of an accurate, experimentally verified theory of wear, fatigue, and critical limiting speed of aircraft tires. Developing a quantitative theoretical understanding and nondestructive measurement techniques for the ductile-brittle toughness transition in time-dependent transparent polymers used in aircraft windshields would be useful as a basis for defining removal criteria in cases of excessive loss-of-impact protection against collisions with flying birds. We seek to understand momentum/energy interaction and morphology and the extent of damage inflicted by ballistic projectiles on fiber-reinforced polymer-matrix composite structure that is immersed in a high-speed airstream.

Computational Fluid Dynamics Research in Turbulence Modeling and Aeroelasticity

DP Rizzetta 13.02.07.07

Wright-Patterson Air Force Base, Ohio

Research opportunities exist to investigate complex high-Reynolds number flow phenomena using solutions of the Favre-averaged Navier–Stokes equations including advanced turbulence modeling. Efforts focus on numerical procedures for solution of the model equations, which may include k-ε and Reynolds stress formulations, and their application to flows which have both fundamental and practical significance. We are also developing methods to predict and analyze aeroelastic behavior by simultaneous time integration of both structural and fluid equations of motion. Interest areas include the generation of numerical structural models, the formulation of algorithms for their solution, and the treatment of dynamic deforming meshes. Computations are performed to simulate fluid/structure interactions and to ascertain details of the solutions, which may be validated by comparison with experimental measurements.

Computational Fluid Dynamics

MR Visbal 13.02.07.08

Wright-Patterson Air Force Base, Ohio

We conduct basic research in interdisciplinary computational fluid dynamics, a technology that is relevant to current and future Air Force systems. Research in unsteady aerodynamics focuses on the accurate simulation and improved understanding of the physical mechanisms that govern complex three-dimensional flow fields encountered by aircraft in the high-angle-of-attack regime. Specific subtopics of interest include (1) topology of three-dimensional vortical flows, (2) vortex breakdown, (3) vortex flow control, (4) vortex/surface interactions, (5) vortex/shock interactions, and (6) bifurcations and hysteresis in vortical flows. Research opportunities exist in the area of turbulence modeling for high-Reynolds number flows employing Reynolds-stress models and large-Eddy simulation techniques. In interdisciplinary computational fluid dynamics, we are developing methods for coupling flight mechanics and aeroelastic equations to simulate the response of aircraft flexible structures to dynamics loading. Opportunities also exist in the areas of computational aeroacoustics and in the solution of the time-domain Maxwell equations, with emphasis placed on higher order numerical algorithms, improved nonreflecting boundary conditions, and massively parallel algorithms.

MATERIALS DIRECTORATE
Wright-Patterson Air Force Base, Ohio

The work of the Materials Directorate spans the total spectrum of technical investigations from fundamental research to production and in-service engineering applications of materials. Within this unique broad and multidisciplinary environment, the scientific challenges of tomorrow are considered to be as important as the technical problems of today.

These scientists and engineers conduct studies that lead to improved performance, predictability, reliability, durability and affordability of materials in demanding applications including the following: synthesis, properties, and morphology of polymers; surface chemistry and physics of composites and electromagnetic materials; electro-optic properties of infrared detector and nonlinear optical materials; structural and high-temperature resistant metals and ceramics; processing science; quantitative nondestructive evaluation; mechanics and life prediction of metals, composites, and adhesively bonded joints; the synthesis and properties of lubricants, protective coatings, and wear surfaces; and environmentally benign approaches.

As a part of the total professional development of the staff, publication of research results in scientific journals and presentation of papers at national and international meetings are encouraged. Several staff scientists are editors of journals and hold responsible offices in professional societies. Since the Directorate is a center of materials technology, its scientists are exposed to current trends in the research and applications of materials. This exposure to leading scientists from universities and industry is an especially important aspect of the professional enrichment of young scientists.

The Directorate also has unique experimental facilities. Each year, new equipment is added including, during the past few years, new laboratory facilities in metals processing, optical measurements, and virtual reality-based materials design. Extensive use of computers and computer-aided testing systems is encouraged.

Chemistry

Aircraft Coatings

MS Donley 13.02.08.01

Wright-Patterson Air Force Base, Ohio

The Materials Directorate has embarked on an Advanced Aircraft Coatings Research and Development Program to ameliorate problems associated with the painting, stripping, and repainting of aircraft. There are specific time-phased near-, mid-, and long-term technical objectives to be achieved in the R&D program, as outlined in the Air Force Coatings Systems Strategy. In the long-term program, two major technology advancements are required: environmentally compliant (nonchromate) corrosion prevention, and extended durability coating systems (30- to 40-year lifetime for primer/surface treatment). The extended durability requirement also involves life prediction and accelerated testing of coatings to ensure that laboratory tests are developed to test actual degradation mechanisms relevant to the specific coating system. A thorough understanding of the chemical origin of coating degradation is necessary for accelerated testing. To accomplish these goals, coating materials science must also be fundamentally understood.

For example, specific projects in corrosion prevention could focus on investigating the fundamental electrochemical interactions of relevant Al alloys, including environmentally friendly corrosion inhibitor electrochemistry. This could also involve investigations of the detailed surface chemistry of corrosion phenomenon on Al alloy metal surfaces, electrochemistry studies, surface chemistry of treated alloy surfaces and effects of the treatments on the alloy grain boundary chemistry, novel surface conversion treatments, and investigations of corrosion inhibitor mechanisms. Specific projects in the extended durability area could center on investigating revolutionary new coating formulation chemistries which provide the 30-year durability. This could involve investigation of synthesis-structure-property relationships of new resin chemistries, detailed analytical examination of environmentally induced chemical changes such as photo-oxidation products generated by ultraviolet light, investigation of transport of corrosion related species through the coating structure, and investigation of the effects of novel surface treatments/ modification such as sol-gel treatments and adhesion promoters. Specific projects in the life prediction area should center on developing new analytical tools which correlate coating lifetime with changes in paint chemistry, and the detection of such chemical changes. Modeling efforts are also of interest, although the available modeling tools may be limited.

Polymer Synthesis

FE Arnold 13.02.08.02

Wright-Patterson Air Force Base, Ohio

We study the synthesis of new aromatic-heterocyclic polymers that are expected to possess high thermal and chemical stabilities. Principal areas include the synthesis and chemistry of specifically structured monomers, the study of polycondensations and other polymerization systems, as required, and the characterization of newly synthesized polymers.

Analytical Chemistry, Lubrication, and Tribology

KJ Eisentraut 13.02.08.03

Wright-Patterson Air Force Base, Ohio

Our research aims to develop new and improved methods for the analysis and characterization of advanced fluid and lubricant materials. Of particular interest are the following: (1) the interaction of fluid and lubricant basestocks and additives with bearing steel metals at various temperatures, (2) the study of mechanisms of additive functionality, (3) the development of improved fluid and lubricant test methods that require much smaller sample quantities yet result in at least the accuracy and precision of current methods, (4) the study of coefficient of friction data with surface films formed at the interface between bearing metals and high-temperature base stocks/additives under conditions of boundary lubrication, and (5) development of fundamental information on the degradation of lubricants. Lubricant materials of primary interest include high-temperature gas-turbine engine oils, new candidate fluids, additives and lubricants, and spacecraft lubricants. Instrumentation available for this work includes Fourier-transform infrared (FTIR), gas-chromatography-FTIR, ultraviolet, and visible spectrometers; a direct-coupled gas chromatograph/mass spectrometer data system; differential thermal and thermogravimetric analyzers; and direct-current and inductively coupled plasma atomic emission spectrometers.

Properties and Processing of Polymers

RJ Spry 13.02.08.04

Wright-Patterson Air Force Base, Ohio

Our research focuses on the mechanical, optical, and electrical properties of polymers, mainly below the glass-transition temperature, and the influence of thermal histories, processing conditions, environmental exposures, and chemical and physical aging on these properties. We measure and characterize physical properties to establish structure/property relationships. Processing of polymers is also investigated from the standpoint of melt rheology of polymers or chemorheology of thermosetting resins. Materials of interest include thermoplastics, thermoset resins, fiber-reinforced composites, molecular composites, nanostructural materials, and sol-gel films. Emphasis is primarily placed on increasing the conductivity of polymeric materials, and on processing nonlinear polymer films for waveguides.

Advanced Fluids and Lubricant Research

HL Paige 13.02.08.05

Wright-Patterson Air Force Base, Ohio

Research on advanced fluids and lubricants focuses on understanding their physical and chemical behavior at the molecular level. We study surfaces that have experienced sliding contacts in the presence of various commercial and experimental fluids. These surfaces are examined using grazing angle Fourier-transform infrared microscopy, x-ray photoelectron spectroscopy, and other techniques, which are employed to characterize surface films and to study the interfacial chemistry between the metal surface and the film. We also use quantum mechanical calculations to elucidate reactions of lubricant fluids and additives, and use molecular dynamics simulations to predict viscosity behavior and other bulk properties of lubricant base fluids. The knowledge gained from these results is used to design improved fluids and additives for lubricant applications.

Synthesis of Organic Third-Order Nonlinear Optical Materials

BA Reinhardt 13.02.08.06

Wright-Patterson Air Force Base, Ohio

We conduct research on the synthesis of aromatic heterocyclic organic compounds and polymers with enhanced third-order nonlinear optical properties. Typical areas of interest include (1) synthesis of uniquely tailored monomers to achieve both high third-order optical nonlinearity and exceptional optical quality; (2) synthesis of model compounds with greatly improved second hyperpolarizabilities; (3) chemistry for the *in situ* formation of cyclic aromatic polymeric structures from acyclic precursors; and (4) basic characterization of monomers, model compounds, and polymers to establish correlations between molecular structures and third-order nonlinear optical properties.

Reference
Reinhardt BA: Trends in Polymer Science 1: 4, 1993

Computational Chemistry/Modeling of Organic Molecules/Polymers

DS Dudis 13.02.08.07

Wright-Patterson Air Force Base, Ohio

Our research focuses on understanding reactions and properties of organic materials for aerospace, structural, and electro-optical applications. Techniques employed range from high-level *ab initio* (with correlation) calculations on small to moderate sized molecules, to semi-empirical and molecular mechanical calculations on larger moieties, to molecular dynamic and Monte Carlo simulations of "bulk" systems. Opportunities exist to apply these techniques to problems in structural and reaction chemistries, physical properties, electrically conducting and/or nonlinear optic materials, or structural polymers with unique properties. Emphasis is placed on predicting candidate materials for actual synthesis, characterization, and testing.

Physics

Surface Science and Thin-Film Materials Research

TW Haas 13.02.09.01

Wright-Patterson Air Force Base, Ohio

Many materials of interest to Air force applications occur in thin-film form and depend on chemical and physical properties of their surface and interfacial regions. In this work, we grow thin films by molecular beam epitaxy (MBE) and pulsed laser deposition (PLD) techniques, and characterize them by a variety of surface analytical techniques. Emphasis is placed on electron and ion scattering spectroscopies and on secondary ion mass spectroscopies. We also characterize surfaces and films using electron and x-ray diffraction, and scanning tunneling microscopy. Current interests focus on thin-film materials for electronic and electro-optical applications. We are particularly interested in MBE grown compound semiconductor epitaxial films for use as infrared detectors and nonlinear optical materials.

High-Temperature Superconductor Films

PM Hemenger 13.02.09.02

Wright-Patterson Air Force Base, Ohio

Superconductor materials with transition temperatures above 90 K are investigated for potential application in infrared detection, microwave circuits, and high-speed electronics. Opportunities exist to study thin-film processing, electrical and magnetic response, theoretical modeling, and device design and performance. Facilities are available for pulsed laser deposition of films, temperature-dependent transport and susceptibility measurements, microwave analysis, surface evaluation, and sample processing.

Physics of Conductivity and Nonlinear Optical Properties of Polymers

RJ Spry 13.02.09.03

Wright-Patterson Air Force Base, Ohio

We investigate the physical mechanisms that produce electrical conductivity in aromatic-heterocyclic polymers. Experimental methods include temperature-dependent conductivity, spectral photoconductivity, drift mobility, photoluminescence, electroluminescence, ultraviolet-visible, near infrared, and Fourier-transform infrared absorption spectroscopy. The results are interpreted using the appropriate molecular and solid-state models.

Polymeric films and solutions are being investigated for use in optical computing, signal processing, and switching. Transmission and scattering losses, refractive index, and other linear optical properties are correlated with morphology. Optical films and waveguide devices are fabricated and analyzed for linear and nonlinear behavior.

Electronic Transport in Semiconductors

WC Mitchel 13.02.09.04

Wright-Patterson Air Force Base, Ohio

Advances in semiconductor growth techniques have made possible the growth of new classes of semiconductors. Thin-film deposition techniques such as molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition can be used to fabricate new materials by controlling structure at the atomic scale. Because of the radically modified band structure and the potential for carrier confinement, unique effects are possible. In addition, wide bandgap semiconductors such as silicon carbide can now be grown in both bulk and epitaxial form. Opportunities exist to study electronic transport in MBE grown heterostructures of III–V materials and silicon carbide. Of interest are studies of the Shubnikov–de Haas effect in type II superlattices (e.g., GaInSb/InAs) and high-temperature Hall effects studies of SiC. Facilities include MBE growth capability, conventional and superconducting magnets for magnetotransport studies in fields up to 9 T, optical characterization techniques, and limited semiconductor processing equipment.

Optical Properties of Semiconductors

DW Fischer 13.02.09.05

Wright-Patterson Air Force Base, Ohio

This research concerns the effects of impurities and defects on the optical properties of bulk and layered thin-film semiconductors. Materials include SiC, ternary nonlinear optical materials such as $CdGeAs_2$, and layered heterostructures (multiple quantum wells and superlattices) of III–V compounds and alloys such as A1GaAs/GaAs and InAs/GaSb. Defects, both grown-in and processing-induced, often absorb radiation in the infrared region. Infrared absorption and photothermal ionization spectroscopies at cryogenic temperatures using various Fourier-transform and grating spectrometers over the 10–12,000 cm^{-1} range, are used for optical characterization and analysis. Primary interest centers on identifying defects and determining their effect on material/device performance. Studies of the band structure of heterostructures by magneto-optical techniques are also of interest.

Guided Wave Electro-Optic Materials

FK Hopkins 13.02.09.06

Wright-Patterson Air Force Base, Ohio

Guided wave electro-optic technology offers enhanced performance for a number of application areas including (1) optical interconnects for high bit-rate data links, (2) phase shifters for phased array radar, (3) phase modulators for fiber-optic gyroscopes, and (4) various other devices such as electric-field sensors and analog-to-digital converters. Lithium Niobate ($LiNbO_3$) is the state-of-the-art material; however, it is limited in several respects. Device fabrication and packaging costs are high; the electro-optic coefficient is low, leading to centimeter size devices; the material cannot be integrated with electronic substrates; and device operating voltages drift with temperature and time. Breakthroughs in several competing material systems are claiming orders of magnitude higher than electro-optic coefficients, and a high degree of thermal and temporal stability as compared to $LiNbO_3$. These material systems include other inorganic ferroelectric materials such as barium titanate and lithium tantalate, crystalline organics, electro-optic poled polymers, and isomorphs of $KTiOPO_4$ (KTP). Opportunities exist to study and develop thin-film deposition and processing techniques, to measure fundamental optical and electro-optical properties, and to model material performance.

Growth and Characterization of Nonlinear Optical Materials

DE Zelmon 13.02.09.07

Wright-Patterson Air Force Base, Ohio

We conduct research on nonlinear optical materials and materials processing for a variety of applications including integrated optics and frequency conversion. Activities include crystal growth, optical waveguide fabrication, study of optical phenomena such as the photorefractive effect, and theoretical modeling. Recent work has focused on new organic, semiorganic, and inorganic bulk materials; polymer waveguides; and wavelength conversion in glass. A variety of physical, chemical, and optical characterization facilities exist including interferometry, ellipsometry, two-wave mixing, waveguide propagation measurements, absorption spectroscopy, Auger spectroscopy, x-ray diffraction, photoluminescence, and wavelength conversion measurements.

Nonlinear Optical Materials/Biomaterials

TM Cooper 13.02.09.08

Wright-Patterson Air Force Base, Ohio

We apply methods and materials from biochemistry to the development of electro-optical materials, and we synthesize polypeptides with properties suitable for use in optical thin films including polyamino acids, proteins, and peptides. These materials are modified with chromophores, liquid-crystal mesogens, or photochromics, and thin films of these materials are obtained. We also investigate the nonlinear optical properties of these thin-film structures in collaboration with the Directorate's physics group. Applicants with a biochemistry/molecular-biology background, who have an interest in solid-phase peptide synthesis, molecular modeling, or biopolymers, are encouraged to apply.

Materials Sciences

Nondestructive Evaluation of Composites

RL Crane 13.02.10.01

Wright-Patterson Air Force Base, Ohio

We conduct research to develop new techniques to nondestructively characterize the microstructure of bulk metals, organic-matrix, metal-matrix, and ceramic-matrix composites. Emphasis is placed on identifying and understanding methods that are capable of isolating or discriminating those microstructural features of importance to the mechanical response of these materials. In the case of organic-matrix composites, examples of these features include the volume fraction of porosity, fiber-matrix bonding, and delamination. A multimodality approach combining ultrasonics, x-ray computed tomography, and thermal imaging is currently receiving the greatest attention. Research is also conducted on optimizing experimental measurements and on developing various image-analysis techniques. Available for this research are ultrasonic, x-ray computed tomography and thermal-wave imaging systems, and modern high-speed computer facilities.

Polymer Physics and Biophysics

WW Adams 13.02.10.02

Wright-Patterson Air Force Base, Ohio

We study molecular structure/microstructure/property relations for new materials that are synthesized by organic or bio-organic techniques for application as laser-hardened materials. Primary approaches are siloxane liquid crystals and liquid-crystal polymer films with nonlinear optical behavior and specifically tailored protein-like molecules with optically active pendant substituents. For multifunctional applications, correlating physical and mechanical properties with structure and morphology is important, but modeling and predicting electro-optical properties are also important. Our primary research purpose is to extend the understanding of current organic systems to the invention of new materials with desirable properties.

Experimental facilities are available in x-ray scattering, electron optics, and atomic-force microscopy. Also available is access to other national facilities such as synchrotron sources, massively parallel computers, and to software for modeling.

Materials Process Design, Control, and Discovery

SR LeClair 13.02.10.03

Wright-Patterson Air Force Base, Ohio

Opportunities are available to establish theories and scientific methods for *in situ* self-directing and self-improving systems for the design and control of material synthesis/processing. Interest areas include (1) the formulation of "intelligent" or closed loop adaptive material processing systems involving multiple sensors and actuators; (2) the generation of new methods and models to integrate material, process, and product design ranging from structural metal, ceramic, and polymer materials; to nonstructural (e.g., lubricants and coatings); to electro-optical and molecular materials; (3) the study of a language and methods of representation to develop integrated, intelligent manufacturing systems; and (4) the study and use of discovery methods to synthesize empirical data in support of autonomous theory formation of first principles associated with advanced materials and processes.

Fracture Mechanics and Fatigue

JM Larsen 13.02.10.04

Wright-Patterson Air Force Base, Ohio

Our research involves developing means of predicting service lives for advanced aircraft and turbine-engine materials, including high-temperature titanium alloys, titanium aluminides, titanium-alloy composites, and ceramic matrix composites under operating conditions using a fracture-mechanics approach. Specific topics of interest include (1) determining the influence of temperature, frequency, mean stress, and load history on fatigue initiation and crack growth including cumulative-damage modeling applied to spectrum loading; (2) environmental effects; (3) small-crack-growth behavior; (4) threshold crack-growth behavior; and (5) crack growth at notches. Interest centers on modeling of time-dependent initiation and crack-growth behavior in titanium-base alloys, intermetallics, and composites, emphasizing relationships between microstructure and properties. Excellent laboratory facilities are available for computer controlled fatigue testing.

High Cycle Fatige Behavior of Materials

T Nicholas 13.02.10.05

Wright-Patterson Air Force Base, Ohio

Research is in progress to characterize the high cycle fatigue (HCF) behavior of structural metals for propulsion systems, with particular emphasis placed on titanium, nickel-base superalloys, and single-crystal alloys. We are interested in the influence of concurrent damage mechanisms on HCF behavior, produced by low cycle fatigue, fretting, foreign object damage, creep, and thermomechanical fatigue. Unique experimental facilities for high-frequency testing are available. HCF research focuses on developing a technology base from which a damage tolerant methodology for HCF can be established.

Metallic Composites

DB Miracle 13.02.10.06

Wright-Patterson Air Force Base, Ohio

We focus on the research and development of advanced metal-matrix composites and intermetallic matrix composites for high-temperature structural applications. Our objective is to understand and control the metallurgical phenomena that take place in the constituents of advanced metallic composites, and to relate these phenomena to composite properties and response. Specific areas of technical interest include (1) determining interfacial properties and the fundamental correlation of interface properties to composite properties, (2) investigating mechanisms of deformation and failure initiation in metallic composites, and (3) modifying the composite constituents to improve composite properties. We use an interdisciplinary approach and establish interactions with groups involved in behavior and life prediction, process modeling, and basic research in advanced intermetallic compounds. Excellent facilities are available to conduct this research including analytical and scanning electron microscopes, electron microprobes, a computerized high-intensity (rotating anode) x-ray diffractometer with high-temperature capabilities, HIP and hot-press facilities capable of producing a wide range of advanced metallic composite specimens, forging and extrusion facilities, single crystal-growth facilities, extensive mechanical testing devices capable of monotonic and time-dependent testing over a wide range of temperatures and environments, and wide range of computational facilities.

Failure Mechanisms in Brittle-Matrix Composites

NJ Pagano 13.02.10.07

Wright-Patterson Air Force Base, Ohio

We conduct analytical studies of failure modes in brittle matrix composites. The work is part of a strongly interdisciplinary activity that includes material science, experimental mechanics, surface analysis, and mathematical modeling. We use the classical theory of elasticity, accurate approximate models for stress-field analysis, failure theories, and fracture mechanics to study both constituent-material and laminate-failure characteristics with particular emphasis on microcracking and the influence of fiber-matrix-interface characteristics on the material response, and on the experimental means to define interfacial properties. We develop a step-by-step, building-block approach, in which important material parameters can be isolated and examined, to provide realistic model validation; we are especially interested in stress-analysis models and delamination of ceramic- and polymeric-matrix-composite materials. We are currently studying various interactive failure mechanisms that occur within the constituents of a composite. Analytical models have been developed and the associated experimental assessment of these models is under way.

Processing Science

SL Semiatin 13.02.10.08

Wright-Patterson Air Force Base, Ohio

Research is in progress to provide the process-modeling tools that exploit the full potential of conventional metals and emerging new materials such as intermetallics, ceramics, and composites using advanced ingot metallurgy, powder, and solidification-process technology. Our objective is to develop advanced physical-modeling capabilities for relating the fundamental laws that govern the processes controlling the evolution of microstructure and the resulting mechanical properties. We emphasize the following: (1) mathematical analyses of unit processes such as extrusion, forging, rolling, and casting; (2) development of numerical models for process simulation on computers; (3) material modeling to understand the material behavior response to process conditions (e.g., phase transformation, fracture behavior); (4) development of constitutive equations for use in numerical models; (5) physical modeling for verification of analytical models; (6) interface-property modeling to represent friction and heat transfer as a function of process variables; and (7) evolution of controlled microstructures during processing.

Ceramic Composites

RJ Kerans 13.02.10.09

Wright-Patterson Air Force Base, Ohio

The goal of this research group is to understand the behavior and design of brittle-matrix composites through the determination and control of processing/ structure/property relationships. Research focuses on determining the role of and controlling the fiber/matrix interface. We are using several approaches to apply fiber coatings, including continuous coatings by sol-gel and chemical vapor deposition. Various methods of manipulating the properties of the coatings will also be examined, including control of the coating microstructure and density during processing, and post-composite-processing reactions to alter coating properties.

We will evaluate mechanics aspects of coating behavior using a physical model composite system which allows isolation, variation, and observation of basic parameters. Such a system will include the use of "micro-tests" which isolate and measure particular properties such as fiber/matrix bond strength, and interfacial friction. This work will contribute to the development of an analytical model, which will be able to predict composite properties, including the fracture process, starting from constituent and interface properties.

Coatings that have appropriate mechanical properties will be used to design one or more high-temperature composite systems. Microstructure/property relationships of coating, fiber, matrix, and reaction layers will be investigated in order to understand the basic principles that determine properties and the evolution of properties with time at temperature and during environmental exposures.

Metallurgy

Aerospace Structural and High-Temperature Materials

DM Dimiduk 13.02.11.01

Wright-Patterson Air Force Base, Ohio

Research centers on understanding the strength, deformation mechanisms, and fracture properties of low-density structural alloys based on metals and intermetallic compounds. Studies involve all aspects of the effects of alloy chemistry, synthesis methods, and phase transformations on the development of microstructure, the mechanical-behavior mechanisms as a function of temperature, and the failure mechanisms of advanced materials. Emphasis is placed on understanding the fundamental synthesis-structure, microstructure-property relationships; modeling these relationships using electronic structure, atomistic, and continuum models; and building from this fundamental information in material design efforts. Applicants are sought for specific projects centered in the following areas: (1) modeling the microstructural influence on deformation behavior of materials, (2) modeling the chemically dependent behavior of dislocation aggregates and their role in dictating the slip character of intermetallic compounds, (3) experiments on developing high-rate vapor deposition processing for understanding nanocrystalline metals, and (4) single-crystal growth of intermetallic compounds. Excellent facilities are available, including analytical electron microscopes, scanning electron microscopes, a high-temperature x-ray diffractometer, a universal induction melting and crystal growth device, melting equipment, a hot isostatic press, forging and extrusion facilities, and a complete range of high-temperature mechanical testing devices and computational resources. Applicants should emphasize innovative and sound approaches to classical structural materials problems through a demonstrated understanding of fundamental materials science and physics.

PHILLIPS LABORATORY
Kirtland Air Force Base, New Mexico
Hanscom Air Force Base, Massachusetts
Edwards Air Force Base, California
Sacramento Peak Observatory, Sunspot, New Mexico

Recognized as a national leader in space research and development, the Air Force's Phillips Laboratory combines a talented military-civilian employee workforce with unique capabilities, resources, and facilities to form a world-class research center for national defense. Phillips is the Air Force's premier laboratory in space research to support combat units. Laboratory scientists work closely with war fighters to identify future defense needs. Once these requirements are identified, salient technologies can be developed, which are then validated, demonstrated, and transferred into operational systems to support the war fighter.

With headquarters located at Kirtland Air Force Base, New Mexico, the Laboratory is charged with furthering research and development in space and missile systems, advanced weapons concepts, and a wide range of geophysics research.

Phillips Laboratory scientists perform in-depth exploitation of the technologies involved in developing spacecraft, ballistic missiles, and directed-energy weapons. The Laboratory places a strong emphasis on integrating and transitioning its technologies into aerospace systems.

The Laboratory concentrates its research and development in the following technical areas: advanced weapons and survivability, geophysics, lasers and imaging, propulsion, and space and missiles technology.

ADVANCED WEAPONS AND SURVIVABILITY DIRECTORATE
Kirtland Air Force Base, New Mexico

The mission of the Directorate is to initiate, prove, and transition to war fighters, directed energy weapons, information warfare, and countermeasures technologies for terrestrial and space combat. Research sources, effects, and weaponization culminate in demonstrations of combat utility.

PROGRAMS

Radio Frequency Weapons Technologies

This research develops and transitions high-power microwave weapons technology into the AF operational inventory and protects US systems against potential radio frequency (RF) weapons threats. Efforts include technology development and demonstrations of advanced HPM weapons, and development and transition of RF hardening techniques to AF Product Centers and industry.

Space Control Technology

This research assesses the vulnerability of foreign space systems to support advanced weapon technology development programs, and defines the hostile threat space environments in which US systems will operate. The challenge is to determine the effects of advanced weapons (such as lasers and high-power microwaves) on both foreign and US space systems, and incorporate these findings into models and computer codes which predict space systems endurability and sustainability.

Engineering, Applied Sciences, and Computer Sciences

High-Power Electromagnetics

CE Baum 13.03.17.01

Kirtland Air Force Base, New Mexico

High-power electromagnetics is concerned with large, fast-rising electromagnetic fields over a large volume, as appropriate to complete military systems. Such environments include the nuclear electromagnetic pulse (EMP), direct-strike lightning, high-power microwaves, and some aspects of transient radar. We focus on antennas and sources to generate the various waveforms and high voltages/currents implied. The fields must be accurately measured (sensors). Research also centers on the interaction of fields with complex structures, for externally scattered fields and for propagation deep into the interior of complex systems, giving rise to disturbing voltages and currents at the circuit level. Available test facilities include EMP simulators, lightning facilities, anechoic chambers, and electromagnetic sensors. There is ample access to computers for theoretical calculations and data analysis.

Reference

Baum CE: Proceedings of the IEEE 80: 789, 1992

High-Power Microwave Source Research

KJ Hendricks 13.03.17.02

Kirtland Air Force Base, New Mexico

Phillips Laboratory is interested in all phases of research and development of new and/or compact high-power microwave (HPM) devices, including initial concept of the device, computer simulation and analysis of how the device will operate, building and testing the device in the laboratory, and demonstrating the device capabilities. As the Air Force premiere research facility for HPM, the Phillips Laboratory collaborates with researchers at Sandia and Los Alamos National Laboratories. We seek Associates with a strong background in any of the following areas: compact pulse power generators, electron beam generation including vacuum diode design, microwave tube design, microwave amplifier design, pulse charging transmission lines with fast switches (including gas, oil, or solid-state switches), design of antenna systems including coupling of the microwave tube to the antenna, design of coupling techniques to allow phase locking of HPM devices, and analytical or numerical modeling of the tasks listed above.

Research focuses on (1) the modulation of annular magnetized electron beams (Gyrotron Backward Wave Oscillator at Phillips, the Relativistic Klystron Amplifier at Phillips and Los Alamos, and the Large Orbit Gyrotron at Los Alamos), (2) the modulation of solid electron beams (Split Cavity Oscillator with Sandia National Laboratories), (3) the conversion of the modulated component of the beam to a traveling wave, (4) the development of high repetition rate switches, and (5) the coupling of the microwave signal to an antenna without reflection or air breakdown. We are also simulating these various devices, improving the computer codes' (EGUN, MAGIC, SOS, and KARAT) agreement with experiment, improving various boundary condition algorithms, and developing parallel PIC codes to speed the simulation of our experimental devices.

Analytical and Computational Research in High Power Microwave Sources

MJ Arman 13.03.17.03

Kirtland Air Force Base, New Mexico

Interaction of intense radio-frequency (rf) radiation with dense high-energy directed plasma is poorly understood. Most conventional analytical techniques are intractable because of the nonlinear nature of the interaction between the rf and the intense charged particle beams, and complex boundary conditions that are involved in high power microwave (HPM) source regions. Finite difference time domain particle-in-cell (PIC) codes have been successfully solving many complex rf-plasma systems. PIC codes inherently include nonlinear effects in plasma interactions, and their general method of treating a wide range of boundary conditions provides a satisfactory solution to problems where other methods fail. We use two- and three-dimensional fully electromagnetic relativistic PIC codes to analyze and develop HPM sources. Computational simulation is also used to study the feasibility of new source concepts, design new and established sources, and to analyze experimental results.

Reference

Villasenor J, Buneman O: Computer Physics Communications 69: 306, 1992

Space and Planetary Sciences

Dynamic Response of Spacecraft to Hypervelocity Impact and Impulsive Loading

FA Allahdadi 13.03.18.01

Kirtland Air Force Base, New Mexico

Characterizing the various failure modes and ultimately the debris environment generated from high-strain rate interactions such as laser illumination, explosion, and hypervelocity collision is an integral part of the space survivability/vulnerability requirement and is essential to the Department of Defense's need of assured access to space. Broadly speaking, the physical processes leading to a breakup and fragmentation may be divided into two distinctive phases: the early-time local hydrodynamics effects and the late-time structural-response effects. Early-time local effects are governed by transient nonequilibrium thermodynamic phenomena; late-time global effects are described by propagation of the transversive stress waves, and material response at high strain rate loading. We perform basic and exploratory research exclusively in high-pressure shock physics, materials sciences, and fracture mechanics to support controlling the processes that contribute to the breakup and eventual formation of an orbital debris cloud. Once the mechanics of breakup are completed, we use predictive models to predict temporal and spatial propagation and dispersion of the debris cloud. We also conduct research to determine the near- and long-term effects of space debris caused by an orbital kinetic-energy-weapon engagement.

Physical Sciences

Compact, Portable Pulsed Power

JH Degnan 13.03.19.01

Kirtland Air Force Base, New Mexico

Research focuses on technology for compact, portable pulsed power and its applications. This includes capacitor driven and explosive pulsed power driven devices; inductive store-opening switch pulse compression; electro-explosive opening switches (fuses); magnetic flux compression with solid and plasma armatures; various types of plasma switches; diode, plasma, solid liner, and compound loads; and various types of intense radiation sources. Potential applications include intense pulsed radio frequency (RF), x-ray, and neutron sources; directed energy concepts; pumping short wavelength lasers; and spacecraft propulsion. Experimental facilities consist of two laboratory buildings with several capacitor banks ranging from tens of kilojoule; tens of kilovolt to 9 megajoules; tens of megamps with risetime consistent with faster versions of explosive pulsed power; a variety of compact Marx banks; RF shielded enclosures with numerous fast transient digitizer and analog recorders for data acquisition; substantial vacuum and power supply hardware; pulsed current, voltage, and magnetic field diagnostics; rotating mirror and gated microchannel plate tube fast photography; optical, RF, vacuum-ultraviolet, x-ray, gamma, and neutron spectroscopy equipment; and an explosive firing site adjacent to one of the laboratory buildings. There are extensive complementary theoretical/computational abilities and resources in the division, including one-, two-, and three-dimensional radiation magnetohydrodynamic and particle-in-cell codes which have been developed, and are being further developed to guide and interpret experiments. We are developing parallel versions of these codes, parallel processing, and high-performance computing techniques.

Computational Plasma Physics

TW Hussey 13.03.19.02

Kirtland Air Force Base, New Mexico

The Phillips Laboratory has a long history of research excellence in the area of theoretical and computational plasma physics. Recently, this group has focused on using developments in supercomputing technology to support in-house efforts to create intense microwave sources and to study various applications of high-energy density plasmas. We are developing physics models and algorithms for large, sophisticated, electromagnetic and particle-in-cell codes adapted to run on massively parallel supercomputers. Applications for such codes include the design of complex narrowband microwave sources as well as power flow in high current pulsed power devices. In addition, we are developing physics models and algorithms for large, multidimensional, radiation-magnetohydrodynamics codes. These codes are used to model a variety of high-energy density pulsed power and plasma devices.

Single Mode Optical Fiber Techniques

SR Restaino 13.03.19.03

Kirtland Air Force Base, New Mexico

Single mode (SM) optical fibers are increasingly used in a variety of fields ranging from imaging to optical computing, and from telecommunications to environmental sensors. We have recently demonstrated new applications in the field of long baseline interferometry. In addition to using fibers for beam relay and transport in both ground- and space-based baseline interferometers, we conduct research in the field of environmental effects on SM fibers for structure monitoring. This research is a joint venture of the Phillips Laboratory and the UK Defense Research Agency. Areas of interest include (1) dispersion control in fibers for broad-band beam transport, (2) beam transport and recombination using SM fibers, and (3) optical path control over several meters of length.

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GEOPHYSICS DIRECTORATE
Hanscom Air Force Base, Massachusetts
Sacramento Peak Observatory, Sunspot, New Mexico

The main focus of the Directorate is to understand the environment between the Earth and Sun, and its effects on military systems and operations. Scientists are interested in space and ionospheric physics, atmospheric and Earth sciences, and optical and infrared technologies. Their products include geophysical models and data bases, design standards, and prototype hardware and software.

PROGRAMS

Space Backgrounds

The Directorate provides principal investigators in natural space backgrounds including the hard Earth, atmosphere, and celestial backgrounds. The data will validate updated models in the Directorate's code, which is used extensively in designing missile-defense surveillance systems.

Radiation Models

The Combined Release and Radiation Effects Satellite (CRRES) discovered a third radiation belt around the Earth while measuring spacecraft anomalies resulting from the radiation environment. A new software package, the first of a number of products based on CRRES data to be released to the spacecraft community, calculates expected radiation for specified shielding thicknesses and orbits.

Weather Impact Decision Aids

Geophysics researchers are developing techniques and prediction models to understand how weather affects the operation of "smart weapons" on the battlefield. Weather impact decision aids translate weather forecasts into system performance impacts. The payoff will increase the percentage of targets destroyed, allow more night missions, and lessen the number of weather aborts over target.

Ionospheric Models

Global, real-time ionospheric and atmospheric density models are being developed for transition to the Air Weather Service to satisfy space command and space track requirements.

Treaty Verification

Seismic studies, to learn the characteristics of man-made and natural vibrations, will contribute to the US's ability to monitor underground nuclear tests for nuclear test ban treaty verification.

Chemistry and Chemical Technology

Excited State Kinetics

DH Katayama 13.03.23.01

Hanscom Air Force Base, Massachusetts

We are conducting exploratory studies on the energy transfer properties of a variety of molecular species of concern to Air Force systems and operations. Research focuses on measuring state specific rate constants when electronic energy is transferred between molecules, from one metastable state to another in an electronic to electronic energy process. Optical-optical double resonance and resonance-enhanced multiphoton ionization techniques are used to investigate state specific collisional quenching data. We also utilize laser techniques to study state specific, inelastic collision processes of molecules in excited states.

Atmospheric Ion Chemistry

AA Viggiano 13.03.23.02

Hanscom Air Force Base, Massachusetts

In the Ionospheric Physics Division, we study low-energy, ion-neutral reactions of interest in the normal and perturbed atmosphere. We measure reaction-rate constants in a selected ion-flow drift tube whose temperature can be varied from 85 K to 600 K and in which reactant ion energies can range from thermal to about 1 eV. Such reactive species as atomic oxygen and atomic hydrogen can be generated and injected into the flow tube for use as reactant neutrals. A high-temperature flowing afterglow apparatus is also being developed for studies of ion chemistry at temperatures above 1,000 K. Reactions of interest include ion-neutral association, associative detachment, charge transfer, heavy particle exchange, and collision-induced dissociation and detachment. We are especially concerned with comparing the effects of temperature, internal energy, and translational energy in driving ion-molecule reactions. We use the information from these studies to develop techniques for chemical modification of free electron densities in the ionosphere and in other plasmas, and to understand the ion chemistry of the atmosphere.

Earth and Atmospheric Sciences

Atmospheric Absorption and Radiance

GP Anderson 13.03.24.01

Hanscom Air Force Base, Massachusetts

The Air Force develops and improves a suite of radiative transfer models to describe the transmittance, scattering, and radiance properties in atmospheric and laboratory environments. Research focuses on developing new algorithms for first principals line-by-line (LBL) models such as FASCODE and its derivatives. The LBL work is integral to understanding atmospheric impacts on laser/lidar systems being developed throughout DOD and the larger national/international science communities. Research also focuses on improving band models such as MODTRAN, which shares FASCODE's aerosol and cloud descriptors, and can model solar contributions. Current studies involve understanding the total energy balance and transfer in a scattering medium including actinic fluxes and action spectra for solar insulation at the surface, cloud absorption and scattering properties in the visible to near infrared, and thermal emissivity properties of the sea surface. Related studies include remote sensing of stratospheric trace species and collaborations with ongoing satellite experiments.

Atmospheric Electricity, Cloud Physics, Design Climatology, and Weather Simulation

AA Barnes, Jr 13.03.24.02

Hanscom Air Force Base, Massachusetts

The cloud physics program concentrates in two major areas: developing improved methods of forecasting both natural and triggered lightning and studying the effects of precipitation and cloud particles on the operation of Air Force systems. Areas of special interest include (1) forecasting particle sizes and concentrations in clouds for application to problems in EO/EM attenuation, vehicle erosion at hypersonic speeds, and the role of cloud microphysics in climate change; and (2) developing electric field instruments that are applicable to solving Air Force problems. Available for this research are radar, satellite, synoptic, and specialized atmospheric data and computers ranging from PCs to CRAYs.

The weather simulation program develops techniques to apply climatic information to the design, operation, and evaluation of Air Force systems. Systems must be designed to operate in and withstand atmospheric extremes of known calculated risk of occurrence. Special observations and field programs are designed to collect unique data. New statistical models are developed to provide probability estimates of weather extremes, areal extent, joint occurrence, duration, and recurrence of weather events that have an adverse effect on Air Force missions. Our efforts focus on developing a computer-simulation laboratory that combines emerging technologies in simulation, such as fractal and chaos theories, and in computer hardware and software capabilities for managing very large data bases. This laboratory will develop (1) environmental-simulation models for spatial and temporal description of meteorological elements, specifically clouds, cloud-free viewing, and cloud size and spacing for various world climatic regions; and (2) scenario models that describe the impact of weather elements on Air Force operations such as the occurrence, recurrence, and duration of intense rainfall impact on satellite communications.

Dynamic Meteorology

CH Yang 13.03.24.03

Hanscom Air Force Base, Massachusetts

The program in dynamic meteorology concentrates on the design and construction of dynamical models of the troposphere and stratosphere on a regional and mesoscale. The models are intended to serve as a vehicle of research with which the dynamics of the atmosphere may be studied and better methods of simulating and predicting the state of the atmosphere may be developed. Current research concentrates on improving analysis and simulation of exchanges, transport, and transition of various phases of water in the atmosphere. We conduct research on representation and parameterization of physical features of the Earth's surface and their effects on the atmospheric processes; we also study impacts of satellite data in analysis, assimilation, and prediction of regional and mesoscale meteorology to develop improved methods for using such data. Diagnostic procedures for assessing and evaluating various components of the numerical models are designed, tested, and applied to global and regional data sets.

Global Ionospheric Modeling

DN Anderson 13.03.24.04

Hanscom Air Force Base, Massachusetts

Basic research studies of the physical processes affecting the ionosphere at F-region altitudes are conducted with particular emphasis on the low- and high-latitude/polar-cap ionospheric regions. Theoretically calculated ionospheric parameters are compared with a large, multitechnique observational data base to determine which are the important physical mechanisms affecting ionospheric change. Investigations include (1) low- and mid-latitude response to geomagnetic storms; (2) high-latitude/polar-cap studies that determine the generation, transport, and decay of polar cap density enhancements or patches and their longitudinal extent; and (3) development of global semiempirical ionospheric models that are both realistic and computationally fast and have the capability of interacting with semiempirical magnetospheric and neutral atmospheric models.

High-Latitude Plasma Structure and Ionospheric Dynamic Coupling

EJ Weber 13.03.24.05

Hanscom Air Force Base, Massachusetts

Research concerns the large-scale structure and dynamics of the polar regions and their relationship to the generation of small-scale (1 km) ionospheric irregularities. This program is primarily experimental: ground, airborne, and *in situ* measurements are combined to yield a physical description of ionization, transport, chemical, and electrodynamic processes. Experiments are conducted both in the auroral oval and polar cap, often combined with multiagency quasi-global measurement programs. The relationship of regions where small-scale ionospheric irregularities are generated to large-scale features (auroral arcs, patches, trough, convection boundaries) is also investigated. Equatorial activities also trigger transport events that can reach middle and high latitudes, significantly distorting ionospheric variations in time and space. Through momentum transfer to ions, the thermospheric circulation perturbation component leads to immediate ion transport changes of major consequences to global scale electron concentrations. Experiments use ground and airborne optical- and radio-wave measurements, often coordinated with incoherent scatter radar, rocket, and satellite observations. New optical diagnostic techniques are studied and implemented. Measurements are compared using numerical simulation codes to test theoretical predictions. Artificial ionospheric disturbances from high-frequency heating and chemical releases are also investigated.

Ionospheric Disturbances and Modification

DE Hunton 13.03.24.06

Hanscom Air Force Base, Massachusetts

The goal of this research is to understand the physics and chemistry of natural and artificial disturbances in the ionosphere that may affect electromagnetic wave propagation from very-low to extremely high frequencies. Ionospheric parameters, such as conductivity, charged-particle composition, and overall structure are measured *in situ*. Quadrupole mass spectrometers and other instruments are flown on balloons, rockets, satellites, and the space shuttle to measure the properties of natural disturbances, such as aurorae, magnetic storms, and polar-cap absorption events. In the ionospheric modification program, the structure and properties of the ionosphere are intentionally changed to study the possible improvement or degradation of communications and surveillance systems. Chemicals, such as barium or sulfur hexafluoride, can be released from rockets or satellites. These chemicals react with the natural constituents of the ionosphere and cause localized enhancements or depletions of the plasma density. The ionosphere can also be modified from the ground with high-powered beams of radio waves. Specific programs are concerned with high-frequency oblique heating and breakdown caused by very-high-power microwave heating. A new facet of the program is the specific study of the role of high temperatures and excited states in the chemistry and physics of weakly ionized plasmas. Laboratory measurements of the reaction rates of ions at high temperatures will be combined with measurements of the properties of high-temperature plasmas and modeling of the plasma characteristics.

Molecular Processes Associated with Spacecraft Contamination

RA Dressler 13.03.24.07

Hanscom Air Force Base, Massachusetts

Gaseous contaminants play a significant role in the environment of spacecraft in low-Earth orbit. The origin of these contaminants, whether ionic or neutral, and their ultimate fate is uncertain. Among the processes of interest in reaching an understanding of the role of contamination in the spacecraft environment are (1) reactions of atmospheric ions with contaminant neutrals at suprathermal energies (corresponding to orbital velocities), (2) oxygen-atom erosion of solid surfaces leading to the generation of gaseous products, and (3) plasma processes leading to the generation of enhanced ionization levels. These problems are studied by an experimental program that includes the study of ion-neutral collisions in a double mass spectrometer and the thermochemical properties of spacecraft material oxides in a high-temperature mass spectrometer using Krudsen cell and laser vaporization techniques. In the ion-neutral program, we determine reaction cross sections using the guided ion-beam technique, and we study the partitioning of reaction energy using time-of-flight techniques and luminescence measurements. In addition to laboratory experiments, we conduct modeling efforts to interpret space-based observations.

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Nonequilibrium Infrared Radiation Processes/I

RD Sharma 13.03.24.08

Hanscom Air Force Base, Massachusetts

We investigate processes leading to infrared (IR) emissions from the mesosphere and thermosphere of the Earth by modeling these emissions, which form the basis of predictive IR radiance codes such as the Strategic High-Altitude Radiance Code. The results obtained from the field measurements are compared with those obtained from the codes, with models refined as needed.

Since new field measurements are being proposed, studies are in progress to show the feasibility of such measurements. Topics currently under investigation include passive remote sensing of atomic oxygen density and temperature as a function of altitude for planetary thermospheres. Future work is planned to remotely sense CO_2 and NO. A number of nonequilibrium phenomena in the planetary thermosphere result from the collisional excitation of IR active molecules (NO, CO, CO_2) and other species (O, N_2) that have large transitional and/or internal excitation. We conduct a program to calculate the vibrational-rotational excitations of molecules in collisions with other species using impulse formalism.

Nonequilibrium Infrared Radiation Processes/II

WAM Blumberg 13.03.24.09

Hanscom Air Force Base, Massachusetts

We perform laboratory research to characterize upper-atmospheric processes that produce infrared (IR) emissions and study chemiluminescent and electron-bombardment-initiated atmospheric IR-emission processes using two unique cryogenic facilities. We also investigate the following: (1) production, quenching, and relaxation of vibrationally excited states of atmospheric species with a flow-tube apparatus using state-specific multiphoton ionization detection; (2) the IR-emission properties of recombining oxygen and nitrogen plasmas produced by laser breakdown; and (3) atmospheric energy-exchange processes using IR lasers that include a tunable diode laser, an F-center laser, and a cw CO/CO_2 laser. Two pulsed laser systems are used to generate tunable ultraviolet and IR radiation for pump-probe investigations of atmospheric IR-emission processes. This laboratory program interacts closely with programs in upper-atmospheric field measurements and theoretical modeling.

Space and Planetary Sciences

Basic Research on Solar Particles

MA Shea 13.03.25.01

Hanscom Air Force Base, Massachusetts

We conduct research on the propagation of solar particles from the Sun, through the interplanetary medium, to the Earth. This research includes acceleration of solar particles to high energies, transport of solar particles in the solar corona, and the release of particles into the interplanetary medium. Extensive solar-particle data from spacecraft and space probes, acquired for the solar-particle catalog, are available for use in various analyses. Studies of the phenomenology of solar proton events and the prediction of the time-intensity profile of these events using other solar-terrestrial physics data, such as for solar radio bursts, optical records, interplanetary magnetic field and plasma measurements, and related geomagnetic data, are being conducted within this research area. Use of computer systems would be expected.

Energetic-Particle Environment

DA Hardy 13.03.25.02

Hanscom Air Force Base, Massachusetts

We conduct research on the energetic-particle environment of near-Earth space. This research includes particles trapped in the magnetosphere, solar-produced radiation, and particle precipitation into the Earth's atmosphere. In addition to analytic methods using existing data from the SCATHA, HILAT, and Defense Meteorological Satellite Program (DMSP) satellites, the energetic-particle environment is treated theoretically by computer simulation in which the trajectories and fields of particles are computed self-consistently. We also study the relationship of precipitating solar-particle fluxes with ionospheric and atmospheric phenomena. Spacecraft instrumentation is designed and flown for programs such as the DMSP and the Tethered Satellite Program.

Experiments in Space Plasma

WJ Burke 13.03.25.03

Hanscom Air Force Base, Massachusetts

We conduct analytical and computer-simulation studies in support of active experiments on the ionosphere and magnetosphere. These experiments are designed to test our understanding of naturally occurring phenomena such as the effects of auroral electron beams and the detrapping of radiation-belt particles. To study auroral processes, electron beams with energies in the low kilo-electron-volt range have been emitted from several sounding rockets. Diagnostic instrumentation has also measured the levels of vehicle charging, local plasma heating, and the spectra of beam-generated waves. Understanding the effects of beam-generated lower hybrid wave on cold background plasmas can elucidate processes that lead to the formation of ion conics that fill auroral field lines with heavy ions during periods of geomagnetic activity.

Plasma Spacecraft Interactions

DL Cooke 13.03.25.04

Hanscom Air Force Base, Massachusetts

We conduct numerous studies of spacecraft-space plasma interactions that include theory, experiment, data analysis, and computer modeling. This opportunity will emphasize computer modeling in conjunction with ongoing space and laboratory experiments. Possible research topics include critical velocity ionization phenomenon; ionization and discharge processes; optical remote sensing; neutral and ionized gas interactions with ambient medium, high-voltage systems; and natural and induced spacecraft charging. We maintain facilities for computing and scientific visualization, as well as a convenient supercomputer access.

Solar Corona and Interplanetary Medium

RC Altrock 13.03.26.01

Sacramento Peak Observatory

Sunspot, New Mexico

In this opportunity, researchers may address problems in the physics of the solar corona, including transient processes and long-term variations in rotation rate, differential rotation, structure, and coronal-hole evolution. We also investigate the impact of coronal phenomena, such as mass ejections and coronal holes, on the interplanetary medium. A data set consisting of daily photoelectric coronograph scans in Fe XIV 5303 covers the period from 1973 to the present, and another set consisting of periodic day-long continuous scans in this line covers the period from 1982 to the present. These data are available for analysis. The prediction of coronal variations and activity is a primary goal of this research effort.

Solar Flares and Activity

DF Neidig, Jr 13.03.26.02

Sacramento Peak Observatory

Sunspot, New Mexico

We investigate problems in understanding and predicting the occurrence of solar activity and the hazards this activity presents to space missions. Research topics in solar flares include observations and analysis of flare optical emissions and magnetic fields as well as theoretical topics related to flare processes or solar atmospheric responses. The facilities are especially suited for studies of flare spectra at high-resolution, high-speed photometry and charge-coupled device imaging in H (or other lines) and vector magnetic field observations.

Solar Physics

GW Simon 13.03.26.03

Sacramento Peak Observatory

Sunspot, New Mexico

Current investigations focus on solar activity processes including solar magnetism, the dynamics of the solar atmosphere, processes that transport and store energy in the solar-atmosphere and subatmospheric layers, methods to obtain improved solar observations, and opportunities to participate in future space missions. The Solar Research Branch is co-located with the National Solar Observatory (NSO) and has access to NSO's array of specialized solar telescopes (e.g., the Vacuum Tower Telescope at Sacramento Peak, a vector magnetograph, several coronagraphs, a complex of activity patrol instrumentation, a medium-sized computing and image-processing facility, and a high-speed microdensitometer). We are developing real-time active optics to enhance the resolution of solar images; and are developing a solar mass ejection imager, and a combined x-ray/extreme ultraviolet light imager for spaceflight.

Spacecraft Atmosphere Interactions

E Murad 13.03.25.05

Hanscom Air Force Base, Massachusetts

We analyze dayglow, nightglow, and spacecraft-atmosphere interactions data from space-borne spectrographs. Over the past three years, we have flown a vacuum spectrograph on four space shuttle flights. The data consist of spectra covering the range 120 to 900 nm at resolutions varying between 0.35 to 1 nm. The applicant would be responsible for analyzing some of this data. Particular interest areas include (1) the morphology of meteor metals and analysis of metal spectra (other than sodium), (2) spectra of plume-atmosphere interactions, and (3) analysis of spectral distributions of various atmospheric species with spectral features in these regions. In some cases, the spectral resolution is sufficient for deducing temperatures.

Physical Sciences

Atmospheric Molecular Absorption Parameters and Investigation of Spectroscopic Tools

LS Rothman 13.03.27.01

Hanscom Air Force Base, Massachusetts

High-resolution molecular absorption parameters from the microwave through the visible region of the spectrum have been compiled on the Geophysics Directorate's HITRAN data base. Research in this area includes theoretical formulations for molecular-transition frequencies, intensities, collision-broadened half-widths, and temperature-dependent parameters that affect calculational schemes simulating atmospheric transmission and radiance. We make high-temperature measurements to develop a "hot-gas" data base for plume simulation, and we also analyze laboratory data and field measurements from which the relevant parameters can be obtained and documented. Research also focuses on measuring molecular spectra and investigating more accurate and precise spectrometric techniques.

Measuring infrared background high-resolution radiance and absorption characteristics of the atmospheric molecular constituents requires the use of spectrometers. Research focuses on measuring molecular spectra and the development of more accurate and precise spectrometric techniques along the following routes: (1) using a two-meter path-difference interferometer and its associated high-temperature cell to study the transmittance of gases at high resolution; (2) enhancing the High-Resolution Spectroscopy Facility by completing a very-high-resolution tunable diode laser system; (3) using the Stratospheric Cryogenic Interferometer Balloon Experiment to obtain daytime and nighttime radiance spectral data of stratospheric molecular gases; and (4) developing existing data-analysis computer programs, new data-analysis techniques, and associated computer software.

Infrared Celestial Background

SD Price 13.03.27.02
Hanscom Air Force Base, Massachusetts

We conduct and sponsor research to characterize large-scale features in the celestial background through a detailed understanding of the constituents. The infrared spectral, spatial, and intensity distributions of astronomical sources are investigated. Furthermore, how these sources relate to the structure of the solar system, galaxy, and the extragalactic background is analyzed. Infrared astronomical sources are studied theoretically, and predictive models are created from which we can depict these objects at any wavelength, resolution, or intensity. The resolution of the existing infrared astronomical data base can be improved with our super-resolution image-enhancement algorithm. Observations may be made with a infrared imaging spectrometer or be obtained by satellite-based telescopes to be flown in the near future. We also wish to extend the predictive capability of our infrared models to the visible and ultraviolet spectral regions.

Upper-Atmospheric Radiation Models

RH Picard 13.03.27.03
Hanscom Air Force Base, Massachusetts

The Earth's upper atmosphere above the altitude of 50–60 km emits copious amounts of radiation in the infrared and visible spectral regions; this is in response to solar-ultraviolet and auroral electron-energy deposition and upwelling radiation from the lower atmosphere. This radiation (airglow) has characteristic spectral and statistical signatures for which we develop theoretical and numerical models. The work is conducted in close collaboration with laboratory and field-measurement programs and includes steady-state and time-dependent photochemistry, radiation transport, electron transport, temporal and spatial statistical structure modeling, and spectral synthesis/analysis methods.

LASERS AND IMAGING DIRECTORATE
Kirtland Air Force Base, New Mexico

The directorate conducts a wide variety of basic research and advanced development programs. Work includes laser devices; advanced imaging techniques; optical systems; acquisition, pointing, and tracking; and ground-based laser antisatellite technologies. The directorate has an active dual-use technology transfer program, finding partners to develop its technologies for other applications.

PROGRAMS

Diode Lasers

Semiconductor laser diodes and diode arrays are being developed at the laboratory.

Diode-Pumped Solid-State Lasers

Research and development is accomplished on solid-state laser materials for alternate wavelengths and optimum efficiencies.

Nonlinear Optics

Current research in this technology focuses on using nonlinear optics to correct atmospheric distortions and compensate for optical imperfections that are common problems in laser and imaging systems.

Chemical Oxygen-Iodine Lasers

Scaling of chemical lasers to high-power levels and improving chemical laser performance is important for various strategic and tactical applications, including space-based scenarios.

Optical Imaging Research

This directorate is the Air Force technology center for all high-resolution optical imaging research, including conventional and nonconventional imaging techniques. It operates national optics facilities such as the Air Force Maui Optical Station and the Starfire Optical Range.

Chemistry and Chemical Technology

Laser Research, Photochemical Processes, and Laser Surface Interactions

LA Schlie 13.03.16.01

Kirtland Air Force Base, New Mexico

We conduct experimental and theoretical research to develop lasers (electric, photolytic, semiconductor diodes, and ultrashort solid-state devices), photochemical processes (thin film, bulk material, and semiconductors), and ultrashort (fs/ps) laser surface interactions. Opportunities exist to investigate the various physical processes in each of these areas. Such research requires detailed experience in laser physics, plasma (discharge) physics, photochemistry, chemical physics, surface physics, solid-state physics, ultrashort laser interactions/diagnostics, solid-state lasers (mode locking/ultrashort pulses), nonlinear laser generation (OPO's, SHG, pulse compression), microwaves, and atomic/molecular physics. The following are potential research areas:

(1) *Laser Research.* We are interested in new methods of producing photolytic, electric, and semiconductor lasers in the ultraviolet, visible, mid-, and near-infrared (IR) region, with particular emphasis on photolytic iodine, HBr/HCl, II–VI semiconductor diodes, and solid-state lasers (e.g., TiS, LiCAF, LiSAF, and Forsterite) as mode locked ultrashort lasers/amplifiers. Nonlinear methods for frequency conversion may also be involved. We will use detailed transient kinetic modeling to determine critical production and quenching processes in conjunction with Boltzmann electron-kinetic analysis. High-intensity flashlamps (dc, pulsed, and microwave-pulsed/cw) sources will be employed in photolytic approaches.

(2) *Surface Interactions.* We are investigating the interaction of visible, near-, and mid-IR ultrashort short laser pulses with photosensitive materials such as PbS, InSb, and HgCdTe in order to understand the carrier dynamics.

Specifically, we will pursue the relaxation of the photogenerated electron carriers, the energy relaxation of these carriers to the lattice temperature, and generated microwave radiation from the nonlinear "hot carrier" interactions. It is also important to understand the basic physical processes. Extensive computer facilities and modern scientific equipment are available for this research.

Physical Sciences

Nonlinear Optics in Thin Films and Other Media

A Gavrielides 13.03.29.01

Kirtland Air Force Base, New Mexico

Both theoretical and experimental research opportunities exist to investigate the interaction of strong optical fields with nonlinear media. These interactions include Raman scattering, Brillouin scattering, four-wave mixing, and beam combining. Theoretical investigations address index-of-refraction variation that is due to the Stark effect and power broadening; possible resonant enhancement of Raman amplification; two-dimensional, four-wave mixing; multimode Raman scattering; and diffractive Raman scattering. Experiments in these areas and in phase conjugation are in progress. Available equipment includes two 150 EST excimer lasers, one quantaray YAG laser, two scanning ring-dye lasers, one 20-W argon-ion laser, one pulsed-dye laser, a high-speed digital boxcar integrator, and three PDP-11 series computers.

We also investigate nonlinear thin films, both experimentally and theoretically, to understand their nonlinear properties and parameters. We conduct these studies to model, develop, measure, and correlate the linear, second-order, and third-order nonlinear properties of thin films. The goal of this work is to optimize the nonlinear response of these films for applications such as phasing diode arrays, beam steering, phase conjugation.

Semiconductor Laser Technology

DA Depatie 13.03.29.02

Kirtland Air Force Base, New Mexico

The Laboratory supports a comprehensive program in developing coherent diode laser sources at various wavelengths and power levels. The semiconductor group works primarily in the GaInAs GaAlAs system, but new materials for 3–5 micrometers that are of interest are being developed. Specific research opportunities exist in optical modeling of laser structures; experimental array dynamics; coupled laser systems including nonlinear coupling; and laser design and realization, including solid state. Growth and processing may be available at the Center for High-Technology Material at the nearby University of New Mexico. In-house facilities include a Ti sapphire laser system, streak camera, computers from lap-top to multiprocessor super computers, laser diagnostics, analytic capabilities, clean room with processing equipment, and an optical fabrication shop. The extensive resources of the Sandia National Laboratory are also nearby, and cooperative ventures are possible.

Advanced Chemical Laser Concepts and Frequency Agile Mid-Infrared Gas Lasers

GD Hager 13.03.29.03

Kirtland Air Force Base, New Mexico

This research involves two areas. The first focuses on developing new chemical laser concepts. We are interested in the possibility of using $NCl(^1\Delta)$ as an energy donor to power the CW iodine laser. In the current version of this laser—the chemical oxygen iodine laser, COIL—iodine atoms are pumped through collisional energy transfer from $O_2(^1\Delta)$, which is produced with two-phase liquid-gas chemistry. By contrast, $NCl(^1\Delta)$ can be produced entirely with gas phase precursors. Thus, an $NCl(^1\Delta)$-I powered transfer laser has the potential to be much lighter than the COIL laser. Research areas include chemical kinetics, laser spectroscopy, and laser physics.

The second area focuses on developing frequency agile gas phase laser sources in the mid-infrared for countermeasures applications, and on optically pumping overtone bands in the hydrogen or deuterium halides. By pumping an overtone band, we produce high-gain inversions and lasing on the fundamental bands, while frequency down-converting the pump radiation. The optically pumped molecules can also be used in energy transfer laser schemes to achieve down conversion and frequency agility. Research areas to develop these laser devices include relaxation processes, kinetics, and laser physics.

PROPULSION DIRECTORATE
Edwards Air Force Base, California

The directorate conducts rocket propulsion research and development activities. The facilities are devoted to advancing rocket engine, component, and propellant technologies.

PROGRAMS

Arcjet Demonstration

Researchers are developing a 226-kilowatt ammonia arcjet capable of propelling a research satellite into geosynchronous orbit. Scheduled to fly in 1996, the technology can also enable stationkeeping and on-orbit mobility of the spacecraft.

Advanced Solid-Axial Stage

The development of a solid-rocket motor is intended for theater missile defense applications. The state, augmented by thrust vector control, provides increased velocity for kinetic-kill vehicles that can intercept enemy missiles.

Clean Propellant

Solid rocket fuels or gels reduce rocket propulsion impacts on the environment. Research includes reducing the use of solvents in manufacturing and providing environmentally friendly, demilitarization procedures.

High-Energy Density Materials

The researchers' goal is to identify and stabilize molecular compounds that have the potential to double the performance of future rocket propellants.

Enhanced Rocket Engine Components

Future spacelift efforts will depend on reliable, long-lived, and efficient rocket engine components. Efforts to reduce the internal friction and simplify complex turbopump machinery are a few examples of a process called Integrated High Payoff Rocket Propulsion Technology. The goal of this process is to double propulsion performance using emerging and enhanced technologies.

Chemistry and Chemical Technology

Novel High-Energy Density Molecular Systems

PG Carrick 13.03.35.01

Edwards Air Force Base, California

We study the formation and characterization of novel high-energy density molecular systems for advanced rocket propulsion and are involved in the production and stabilization of atomic and molecular species dispersed in cryogenic matrices, corona- excited supersonic expansion production of small energetic free radicals, ions and chemically bound excited-state molecules. The atomic and molecular systems of interest consist of Li, B, C, Mg, and Al in the form of atoms or diatomic and small polyatomic molecules. We study the molecular properties of these systems by optical and laser techniques such as pulsed and continuous laser-induced fluorescence, optical absorption using a gated, intensified optical multichannel analyzer, infrared absorption and emission using a Fourier-transform spectrometer, and resolved optical emission using long-pass and vacuum-ultraviolet monochromators combined with photon-counting techniques. Trapping and stabilization of these high-energy content molecular and atomic systems in cryogenic solids could vastly improve the specific impulse of existing propulsion systems, permitting single-stage-to-orbit missions and increased payload capabilities.

Reference

Brazier CR, Carrick PG: Journal of Chemical Physics 96: 8684, 1992

Structure and Spectra of van der Waals Molecules

SL Rodgers 13.03.35.02
Edwards Air Force Base, California

One way to stabilize high-energy species is to store them in a cryogenic liquid or solid. Our goal is to stabilize reactive species by coating them with one or more layers of protective atoms or molecules, which are bound to them by weak forces commonly called van der Waals interactions. We calculate interaction energy surfaces and may use them to perform dynamics calculations. To observe these protected species spectroscopically, we must be able to predict relevant infrared, Raman, and electronic spectra. We do this by using *ab initio* quantum-mechanical computations, which are substantially more exact than computations of chemically bound species. The computational chemistry group has substantial access to CRAY 2, CRAY YMP, and various parallel computers that are located at remote sites; and an array of high-powered workstations for local use.

Reference

Rosenkrantz ME, Bohr JE, Konowalow DD: Theoretica Chimica Acta 82: 153, 1992

Synthesis and Propellant Chemistry

CI Merrill 13.03.35.03
Edwards Air Force Base, California

Research is directed toward obtaining stable, high-energy ingredients for advanced rocket propulsion. Suggested fields of research include (1) synthesis of nitroform-derived oxidizers, dinitramide oxidizers, and caged nitramine oxidizers; (2) decomposition kinetics of energetic ingredients and stabilization for use in solid propellants; (3) polymer-cure chemistry for optimum mechanical properties and solid fillers; (4) solid-state chemistry to permit optimum bonding of solids with elastomers; (5) combustion mechanisms of composite solid propellants to increase rocket motor efficiency; (6) enhancement of binder toughness and mechanical properties by modification of prepolymer/curative structural properties; and (7) high-energy material hazards mitigation.

Combustion Kinetics and Rarefied Gas Dynamics

DP Weaver 13.03.35.04

Edwards Air Force Base, California

Kinetics research focuses on identifying the specific chemical-kinetic mechanisms that influence the combustion behavior of nitramine, AP, AN, and double-base solid and solution propellants. Research opportunities exist in (1) the application of laser-diagnostic techniques in high-pressure, laboratory-scale nitramine and double-base propellants; (2) the chemical-kinetic modeling of nitramine and double-base propellant decomposition at high pressure; (3) the experimental and theoretical investigations of the controlling chemical-kinetic mechanisms in laboratory high-pressure CH_4/NO_2 and CH_2O/NO_2 flame systems; and (4) the specific flame chemistry of metal (aluminum)-oxide laboratory flames at high pressure.

Investigations emphasize the study of the detailed collisional-energy exchange processes that occur in the vacuum expansion of high-velocity gas flows and understanding the key molecular mechanisms of formation for species formed in the plume at altitudes greater than 90 km. The following specific research opportunities exist: (1) laser- and electron-beam diagnostic applications in the low-density gas expansions of nonreacting diatomic, noble-gas, and reacting-gas expansion flows; (2) investigation of the collisional mechanisms governing high-speed atomic/molecular interactions and their influence on subsequent infrared and ultraviolet radiation at low densities; (3) the study of the influence of nonequilibrium internal energy state distributions and condensation processes on the scattering (collisional) processes in the nozzle lip and mixing regions of rarefied flows; (4) the influence of rarefaction effects on the specific chemistry that produce ultraviolet radiation at high altitudes; and (5) direct Monte Carlo simulation of rarefied expansion flows.

Atomic Additives to Cryogenic Solid Propellants

ME Fajardo 13.03.35.05

Edwards Air Force Base, California

Our objective is to produce and characterize laboratory scale samples of high-energy density matter which will be used in novel, high-performance chemical propulsion systems. Our immediate objectives are (1) to develop techniques for stabilizing light atoms (H, Li, B, C, N, Mg, Al, Si) in cryogenic solid hydrogen, (2) to determine the relevant properties of these materials (i.e., microscopic structures, chemical and thermal stabilities, energy storage capacities), and (3) to maximize the concentrations of energetic species in solid hydrogen. Using both experimental and theoretical tools, we hope to make direct comparisons between the results of condensed phase spectroscopic experiments and of molecular dynamics or Monte Carlo simulations.

References
Fajardo ME: Chemical Physics 189: 351, 1994
Fajardo ME: Applied Physics Letters 65: 159, 1994

Materials Chemistry and Processing Science of Hybrid Plastics

JD Lichtenhan 13.03.35.06
Edwards Air Force Base, California

We conduct chemical synthesis and processing research on a variety of polymeric materials. Of particular interest are polymers with hybrid (inorganic-organic) compositions, as these materials possess a range of properties desirable for Air Force Rocket Propulsion applications.

Synthetic research focuses on the preparation of polyhedral oligomeric silsesquioxanes (POSS) and polyhedral oligomeric metallosesquioxanes (POMS) precursors, monomers, and polymers. Research involves improving the synthesis and control of POSS/POMS cage-structure and their functionality. Condensation and addition polymerization chemistry of both POSS and POMS monomers is pursued and covers all classes of polymeric materials. Properties investigation and structure-property relationships are identified for the various POSS-polymer compositions and architectures.

Research on the processing and characterization of polymer blends is also in progress. The goal is to understand the morphology development with regard to processing conditions for polymer blends and for immiscible blends of interest for Air Force Rocket Propulsion. Processing and characterization methods (e.g., rheological microscope) are used to identify processing-property relationships in these materials.

Engineering, Applied Sciences, and Computer Sciences

Fracture Mechanics and Experimental Mechanics

CT Liu 13.03.36.01

Edwards Air Force Base, California

The overall objective of this research is to gain an advanced understanding of fracture and crack-growth behavior in solid propellants and to develop methods to predict crack growth. The emphasis is on mechanisms and mechanics involved in fracture and crack growth in solid propellants and at interface bond lines. Specific topics of interest include (1) nonlinear modeling and methods for predicting crack growth, (2) mixed-mode fracture, (3) adhesive and cohesive crack-growth behavior in the presence of material gradients, (4) environmental effects, (5) nondestructive testing and evaluation of solid propellants, (6) probabilistic approach to fracture, (7) time-series analysis, and (8) fatigue of solid propellants. Excellent laboratory and computer facilities are available for experimental and analytical investigations.

High Pressure and Supercritical Combustion

DG Talley 13.03.36.02

Edwards Air Force Base, California

The objective of this work is to investigate atomization and combustion of liquid propellants at high pressures including supercritical pressures. Current understanding of spray combustion processes is based mostly on low pressure, subcritical mechanisms, whereas future Air Force propulsion and other combustion applications will increasingly emphasize high pressures. Atomization and spray combustion mechanisms may be different in these regimes. At pressures exceeding the critical point of the propellant (731 psi for liquid oxygen), the sharp distinction between gas and liquid phases can entirely disappear, and we can question whether droplets can even exist. Such flows will likely exhibit properties, which at some times are like those of turbulent jets and at other times are more like those of sprays. Even under subcritical, high pressures pose substantial challenges for combustion diagnostic techniques, most of which were developed for low-pressure applications. Obstacles such as dense sprays, beam steering, molecular quenching, and spectral line broadening need to be overcome. Numerous research opportunities are available to work with an established team of scientists and engineers to improve technology in this area.

Plasma Physics of Electric Propulsion Devices

SL Rodgers 13.03.36.03

Edwards Air Force Base, California

The objective of this research is to investigate the operating physics of electric propulsion devices as a way to improve thruster performance. Important study areas include plasma physics, plasma-power system coupling, internal energy distribution, arc ignition, and heat transfer. Research efforts include experimental and numerical modeling of the pulsed plasma thruster (PPT), Hall-effect thruster, ion engine, and magnetoplasmadynamic thruster. Current PPT research focuses on the identification and quantification of thruster loss mechanisms, and the development of improved thruster and power system designs. The diagnostics that we employ include pulsed and continuous laser-induced fluorescence, laser interferometry, Langmuir probes, emission spectroscopy, thrust stand, and high-speed camera systems.

Physical Sciences

Materials Science of Carbon Composites

WP Hoffman 13.03.37.01

Edwards Air Force Base, California

Although carbon composites are excellent structural materials, research is needed to extend their use into different applications and environments. The thrust of our research is two-fold: (1) to understand the interface between carbon and refractory materials to improve carbon's oxidation resistance and (2) to understand the carbon fiber-matrix interface so that the mechanical properties of the resulting composite can be improved. Research has focused on enhancing surface reactivity of carbon fibers to improve their bonding, on the use of chemical vapor deposition (CVD) for the deposition of carbon-on-carbon substrates, and on the CVD of oxidation-protection coatings on carbon substrates. Our scanning tunneling microscope and atomic force microscope have been extensively used to characterize the surface morphology of the carbon-fiber surface down to the atomic scale and to document the effects of various fiber surface treatments. Devices and composites are also

fabricated from microtubes that have been developed in our laboratory. These tubes can be made in various cross-sectional shapes from practically any material. To date, microtubes with an ID as small at 0.1 µm have been fabricated, although the lower limit is thought to be 5 nm. Microtubes may be made free-standing or may form tubes or channels in monolithic bodies.

SPACE AND MISSILES TECHNOLOGY DIRECTORATE
Kirtland Air Force Base, New Mexico

The directorate develops, integrates, demonstrates, and transitions reliable leading-edge space and missile technologies.

PROGRAMS

Advanced Space Electronics Technology

This major thrust focuses on research and accelerated development of radiation-hardened, high-performance, standardized producible electronics for space applications.

Ballistic Missile Technology

This program focuses on a spectrum of technologies necessary for upgrades to current missiles, which improve performance, increase reliability, and reduce operations and maintenance costs.

Satellite Control and Simulation Technology

Research focuses on reducing life-cycle costs and improving overall space-systems performance. Current projects include intelligent, object-oriented satellite-control architecture; reusable software-component technology for satellite systems; and the incorporation of space systems and environments into war-gaming simulations.

Space Power and Thermal Technology

Research efforts involve lightweight solar arrays, sodium sulfur batteries, active cryocoolers, and heat pipes. An interactive space-power program examines bimodal power and propulsion, and high-temperature technologies.

Space Sensors and Satellite Communications

Researchers work in next generation technologies in infrared focal plane arrays, advanced communications, and novel radar-processing algorithms to meet the Air Force's deficiencies in surveillance and remote sensing.

Structures and Controls Technology

The foundation is being developed for "smart" space structures: composite materials with sensors and actuators that suppress vibration, control shape, and provide self-monitoring.

Space and Planetary Sciences

Precision Space Structures Dynamics and Control

A Das 13.03.14.01

Kirtland Air Force Base, New Mexico

Many of the planned space surveillance and defense platforms require precise pointing and vibration control to meet their mission needs. One to two orders of magnitude reduction in line-of-sight jitter is typically required to fully meet the pointing requirements. The vibration/pointing control system is also required to operate autonomously over extended periods of time within minimal ground support. We anticipate that over the life of the mission many critical parameters required by the control system will significantly change with time, resulting in serious degradation in performance. Such changes can result from a combination of factors including (1) gradual aging of the structural components of the platform, (2) sudden changes resulting from interaction with certain natural/threat environments, and (3) changes in the components of the control system itself (e.g., sensors and actuators). Thus, vibration suppression systems will be required to autonomously track these changes and retune themselves in order to deliver required performance. This research emphasizes both the theoretical developments and experimental verification at Phillips Laboratory facilities.

Survivability Technology for Space Systems

BK Singaraju 13.03.14.02
Kirtland Air Force Base, New Mexico

The Air Force is interested in developing survivable and autonomous communications technologies in support of space systems. Specific technology developments of interest are (1) survivable high-data-rate space-based information processing, (2) nuclear and other effects on electronic systems and the techniques for mitigating them, (3) modeling in stressed environments and the techniques for improving modeling electronics, and (4) application of artificial intelligence and neural network techniques for space systems. Available for this research are computer simulation tools, an electronics laboratory to perform experimental work, and hardware-in-the-loop modeling stressed environments such as jamming and scintillations.

Physical Sciences

Infrared Detectors and Readout Electronics

V Nathan 13.03.40.01
Kirtland Air Force Base, New Mexico

We perform theoretical and experimental research on infrared detectors and associated readout electronics. We investigate the electronic and optical properties of HgCdTe detectors, GaAs/AlGaAs quantum well detectors, and MOSFETs under benign and radiation environments. We are also studying the following topics: anomalous dark current in GaAs/AlGaAs quantum well detectors; dependence of gain, responsivity, and noise of HgCdTe detectors on parameters such as passivant, doping, bias, and temperature; hot electron effects in MOSFETs at cryogenic temperatures; and the effects of space radiation (e.g., gamma, electron, proton, neutron, and x ray) and lasers on these devices at room temperature and cryogenic temperatures. The goal is to increase our understanding of the physical mechanisms that control the performance of these devices under benign and radiation environments. This increased understanding will enable us to develop infrared detectors and readout electronics with improved responsivity and gain, reduced noise, and dark current and enhanced hardness to space radiation and lasers. We are collaborating with the University of New Mexico and the Aerospace Corporation.

Space Environmental Effects on Spacecraft Materials

C Stein 13.03.40.02

Kirtland Air Force Base, New Mexico

The low Earth space environment consists of several variables which are extremely deleterious to spacecraft materials. The objective of both theoretical and experimental studies is to understand the fundamentals of the interactive mechanisms and the manner in which their synergistic effects accelerates the degradation of composite spacecraft materials. The low Earth orbit environment consists of energetic particles such as electrons and protons, oxygen atoms, ultraviolet radiation, x rays, and hypervelocity debris particles. Other researchers have studied the effects of oxygen atoms and oxygen atoms in conjunction with ultraviolet radiation; they have found that synergistic effects between these two variables almost doubles the mass loss rates from composite materials. To date, we have not studied the concomitant effects of the remainder of the space environmental variables. The Phillips Laboratory has developed a technique to project small debris particles at 8 km/sec inside a mass spectrometer so that we can investigate the nature of the chemical species produced by the impact. We have also developed a computer model of the shock wave produced. Our goal is to combine this technique with the other space environmental factors, which will allow us to closely reproduce the effect of space on spacecraft materials. Understanding the fundamental chemical processes by which spacecraft materials degrade and lose mass by each of the space environmental variables in low Earth orbit will enhance their survivability. Fundamental research and computer modeling is encouraged in the area of interactive chemistry of composite materials with electrons, protons, atomic oxygen, ultraviolet, and hypervelocity debris.

Computational Plasma Physics

TW Hussey 13.03.40.03

Kirtland Air Force Base, New Mexico

The Phillips Laboratory has a long history of research excellence in the area of theoretical and computational plasma physics. Recently, this group has focused on using developments in supercomputing technology to support in-house efforts to create intense microwave sources and to study various applications of high-energy density plasmas. We are developing physics models and algorithms for large, sophisticated, electromagnetic and particle-in-cell codes adapted to run on massively parallel supercomputers. Applications for such codes include the design of complex narrowband microwave sources as well as power flow in high current pulsed power devices. In addition, we are developing physics models and algorithms for large, multidimensional, radiation-magnetohydrodynamics codes. These codes are used to model a variety of high-energy density pulsed power and plasma devices.

Research and Development in Passive Sensors and Laser Communications

DA Cardimona 13.03.40.04

Kirtland Air Force Base, New Mexico

Research opportunities in the Passive and Active Sensors Branches of the Space and Missiles Technology Directorate are extremely varied. We have broad charters to investigate all aspects of component technology and development for laser communications, and passive sensor development and characterization in the wavelength range from infrared to ultraviolet. In optical communications, opportunities exist for research in modulation, detection, and analysis technologies for high-data rate transmissions; in the development of multiuser optical fiber components and laser diodes; and in the application of broad-band superfluorescent fiber sources in novel sensor systems. In the passive sensor area, experimental and theoretical research focuses on new detector development, focal plane array readout electronics, and the radiation hardening of all system components. Although we are interested in the possibilities of all-optical readout of the focal plane array and in II–VI compound semiconductor structures, we are currently concentrating on long wavelength infrared detectors based on intersub-band absorption in III–V semiconductor multiple quantum well and superlattice heterostructures. Topics under investigation include dark current production, quantum transport of electrons through the heterostructure, and optical coupling into the quantum mechanical structures. Available experimental characterization techniques include Fourier-transform infrared spectroscopy, Hall effect and deep level transient spectroscopy, transmission electron microscopy, and x-ray diffraction. Our testing and research laboratory also contains all the equipment necessary

to completely characterize detector/readout performance at cryogenic temperatures.

ROME LABORATORY
Griffiss Air Force Base, New York
Hanscom Air Force Base, Massachusetts

Rome Laboratory is the Air Force's principal laboratory for research and development in Command, Control, Communication, Computing, and Intelligence (C4I) technology. Headquartered in Rome, New York, the Laboratory has research activities both in Rome and in Bedford, Massachusetts. Both operations sustain some of the finest laboratory and research facilities to be found anywhere. The majority of Laboratory researchers have earned advanced degrees, typically in physics and electrical engineering.

Rome Laboratory research concentrates on a wide range of programs which include radio, optical, and space communications; software engineering for command and control (including knowledge-based systems and artificial intelligence); radar and infrared surveillance of ground and airborne objects; software applications for intelligence-data collection and handling; theoretical and experimental aspects of solid-state sciences; photonics, ranging from basic physics to component development; antennas and propagation aspects of electromagnetics research; and reliability physics with emphasis on electronic components and systems.

Three of the four Laboratory directorates participate in the NRC Research Associateship Program: the Surveillance and Photonics Directorate; the Command, Control, and Communications Directorate; and the Electromagnetics Reliability Directorate.

SURVEILLANCE AND PHOTONICS DIRECTORATE
Rome, New York

The Directorate of Surveillance and Photonics develops advanced wide-area surveillance capabilities to detect, track, and identify ground and aerospace threats. Surveillance technology includes advanced radars, passive sensors, electronic support measures throughout the radio spectrum, sensor fusion, phased arrays, signal generation, reception and control components, embedded processors, and signal-processing techniques. The directorate also develops photonics technology for the full spectrum of command, control, communications, and intelligence applications.

Analog Optical-Signal Processing

GA Brost 13.23.01.01

Rome, New York

This program focuses on investigating adaptive optoelectronic system concepts and device technologies for analog processing of one- and two-dimensional signals. For example, we use photorefractive processes in thin film and quantum well semiconductors to perform high speed, frame parallel, optical pattern recognition. Current characteristics of these materials indicate performance at frame rates approaching 1 MHz with 30 micron resolution Alternatively, optoelectronic neural network processors are constructed to speed up the recognition task. We develop spatial light modulators, diffractive optical elements, and acousto-optic processor designs to support this research. An opportunity exists to use adaptive radar signal processing for optical signal processing devices, and to control the interfaces between the detected signal, the optical processing devices, and the host system. Available equipment includes a TiSaph laser, other lasers emitting at wavelengths from the visible into the near infrared, an optical multichannel analyzer, and an optical spectrum analyzer.

Optical Interconnects

RK Boncek 13.23.01.02

Rome, New York

The Photonics Research Center is investigating techniques to exploit the immense bandwidth for communication systems available on optical fiber systems. These systems are envisioned for multiprocessor interconnects in distributed data fusion environments and for analog radar antenna remoting. We are developing components and devices to perform multiplexing in the time, wavelength, or frequency domains on optical carriers. Recent work demonstrated 2.5 Gbit/sec performance in an ATM crossbar switch in lithium niobate electro-optic switches driven by high-speed silicon circuitry in a distributed control architecture. Future work will extend this capability to 10 Gbit/sec; the speed of electronic control circuitry constitutes the perceived limitation. Work is also in progress to develop an FM analog lightwave transmitter for antenna remoting at modulation frequencies beyond 10 GHz; its performance echoes requirements for CATV and cellular telephone signal transmission. Specific on-site equipment consists of a 1.2 psec pulsed Nd:YLF laser emitting at 1.3 microns, a 5 Gbit/sec error rate tester, and a 40 GHz network analyzer.

Adaptive Detection Architectures for Time-Varying Processes

VC Vannicola 13.23.01.03

Rome, New York

Research focuses on detecting and estimating radar signals contained in observation data with low signal-to-noise levels. Emphasis is placed on the physically realizable detection architectures amenable to adaptivity in time varying (nonstationary) processes. Our objective is to investigate implementable architectures and algorithms in order to improve detection performance in radar environments characterized by low signal levels embedded in a dense clutter background. Approaches involve estimation algorithms and architectures, locally optimum detection methods, distributed sensors, model-based detection, alternate detection approaches, generalized likelihood ratios, constant false alarm rate detection, adaptive Doppler filtering, and nonlinear estimation methods. Prime consideration will be given to analyses that consider the observation process as nonstationary, and not necessarily with Gaussian statistics.

Multichannel, Parametric, Model-Based Methods for Adaptive Processing

JH Michels 13.23.01.04

Rome, New York

Classical approaches to space-time signal processing in sensor array applications have involved the estimation of the interference covariance matrix.

Together with an assumed signal steering vector, this estimate is used to obtain the matched filter weights which maximize signal-to-noise ratio. Multichannel parametric models of such processes contain the spatial and temporal correlation properties within their complex parameters. Furthermore, models of low order often provide adequate process representation. Thus, parametric estimation algorithms operating directly on the data provide the capability to achieve efficient space-time processing.

This research will focus on developing multichannel parametric, model-based methods for detection, estimation, and system identification applications. Our prime objective will be to investigate implementable architectures and algorithms for both multiple sensors and sensor arrays. The phase array radar sensor is the principal application area. However, the development of methods applicable to dual-use technologies (e.g., biomedical) are also encouraged. This work will include generalized likelihood methods, whitening techniques, time series and state-space approaches, adaptive space-time algorithms, change detection approaches, and adaptive filtering.

Optical Components and Subsystems for Distributed Signal Processors and Smart Communications Networks

MA Parker 13.23.01.05

Rome, New York

Research centers on the design, fabrication, and testing of novel opto-electronic integrated circuits. Current work involves cross-coupled semiconductor lasers and spontaneous emission filters, amorphous silicon and low-temperature GaAs optical memory elements, Q-switched semiconductor lasers with detector driven modulators, FETs integrated with VCSELs and in-plane lasers, and various integrated detector and waveguide circuits. The devices and subsystems are for distributed optical signal processing and smart communications systems, which include packet switching, optical backplanes, and optical neural networks. Six researchers collaborate on the above areas. The design and testing is performed at the Rome Laboratory, while the fabrication is accomplished at the National Nanofabrication Facility at Cornell University.

COMMAND, CONTROL, AND COMMUNICATIONS DIRECTORATE Rome, New York

The Command, Control, and Communications (C3) Directorate conducts research in software tools for high-performance computers, computer security, knowledge-based systems, decision aids, distributed computing systems, seamless communications, network management and evaluation, multimedia transmission and presentation, and in C3 evaluation. This work is conducted entirely in Rome, New York.

The C3 Directorate is well equipped with computer and software resources to support the requisite research, including access to supercomputers and massively parallel machines. The Laboratory conducts considerable in-house research, supported by a substantial contractual program component.

Principal research activities under the NRC Research Associateship Program will concentrate on advanced planning and scheduling, as described in the following research opportunity.

Accounting for Uncertainty in Planning

JF Lemmer 13.23.04.01

Rome, New York

Research focuses on the integration of qualitative and quantitative uncertainty into artificial intelligence-based planning techniques, using both automatic and interactive planning procedures. When plans are developed, we are never certain of the future state of the world (e.g., weather), preconditions for action (e.g., availability of supplies), the actual versus intended outcome of actions (e.g., bombing a bridge to block transportation), and the reaction of an adversary (e.g., intensify defensive counter-air). We seek to develop methods of accounting for such uncertainties within computationally feasible planning procedures applicable to medium- and large-scale military problems.

Communications Technology for Broadband Mobile Connectivity

DJ Nicholson 13.23.04.02

Rome, New York

The commercial utility of optical carriers is evident in the widespread use of fiber-optic links. For mobile use, the most widely used technology is satellite-based radio frequency linking. As we see the rapid growth of applications requiring connectivity to mobile platforms separated by wide and varying distances, it is evident that expanded trunk connectivity is required, and that these connections must be able to support wideband signals in a variety of formats.

The ATM (asynchronous transfer mode) format has many desirable characteristics for support of simultaneous voice, video, and data traffic. We wish to explore the possibilities and limitations in an ATM switched network, using the combined resources of our satellite testbed and the existing fiber network capability in our network laboratory. Topics under investigation include behavior with a fading channel, source stabilization employing model reference controls, and subcarrier signal distribution in a local but spatially varying network.

ELECTROMAGNETICS AND RELIABILITY DIRECTORATE
Hanscom Air Force Base, Massachusetts

The Electromagnetics and Reliability (ER) Directorate of Rome Laboratory is headquartered in Bedford, Massachusetts, where the principal research in electromagnetics and solid-state sciences is performed. Reliability studies within this directorate are located separately in Rome, New York, where electronic component and system reliability is researched.

In the electromagnetics program, the directorate conducts research and development in electron-device technology, electro-optics, electromagnetic materials, and in related technologies in solid-state sciences. Specifically, research is conducted in Shottky-barrier infrared detector arrays, optical signal processing, superconductivity, advanced antennas (including techniques employing neural networks and digital beam forming), guided-wave optics, solid-state materials processing, nonlinear materials and effects, and photonic materials.

The ER Directorate has facilities in crystal growth and characterization (including the ability to grow one-of-a-kind crystals), Shottky-barrier device characterization, electro-optical component preparation and measurement, and in cryoelectronics. Unique facilities are available to support antenna performance and electromagnetic propagation measurement, including a number of electromagnetically "quiet" field sites.

Advanced Antenna Technology

H Steyskal 13.23.07.01

Hanscom Air Force Base, Massachusetts

Research opportunities exist in the area of high-gain scannable and multibeam antennas to support Air Force air- and spaceborne radar systems. There are four topics of interest. The first one focuses on array-fed reflector and lens configurations, which offer the potential for an electrically scanned, high-gain beam at low cost. We are also interested in electromagnetic modeling of such systems, and the conventional pattern and aperture syntheses of very-short-pulse patterns with prescribed spatial and temporal characteristics, including pulses for which a carrier frequency cannot be defined (e.g. focus waves).

A second topic addresses microstrip-array antennas. These are attractive because the elements are simple and essentially two-dimensional, and the arrays can conform to both planar and curved surfaces. Mathematical models are required for these arrays, complete with their feeding networks and packaging.

A third topic centers on computational electromagnetics for electrically large bodies. We need to improve both frequency and time domain methods, which eventually will permit us to numerically analyze such complex problems as a microwave antenna on an aircraft and to maintain accuracy over a 60 dB dynamic range.

Electromagnetic Scattering

AD Yaghjian 13.23.07.02

Hanscom Air Force Base, Massachusetts

We develop basic methods for predicting and measuring scattering from random surfaces and bodies of general shape, size, and composition in both the frequency and time domains. The statistical nature of the scattering and its dependence on frequency and polarization are significant. Methods for predicting scattering include, but are not limited to, high-frequency diffraction, surface-integral-equation, volume-integral-equation, transform-iterative, and finite-difference or -element techniques. We emphasize the accurate determination of the complete scattering characteristics of multiwavelength, second-generation canonical shapes (to act as benchmark and calibration solutions for general computer codes and bistatic cross-section measurements) and the diffraction at all angles of incidence and observation from antennas and scatterers. An additional interest is the relationship between the statistical nature of the scatterer and the properties of the scattered field. To complement the theoretical effort, we are developing both near- and far-field techniques to measure the radiation and scattering characteristics of arbitrary antennas and scatterers.

Optical-Signal Processing: Algorithms, Devices, and Materials

JL Horner 13.23.07.03

Hanscom Air Force Base, Massachusetts

Our research concerns new approaches to pattern-recognition schemes (algorithms) and systems for their implementation (architectures and devices). We are developing new, optimized, correlation filters for target detection, acquisition, and tracking (e.g., the phase-only and binary phase-only filter, composite filters, and nonlinear filters). We also work on spatial light modulators and (most recently) smart pixel SLMs. Research focuses on nonlinear optical materials such as photorefractive crystals, and on nonlinear effects in atomic beams, with application to optical storage systems.

Schottky-Barrier Infrared Imagery

J Silverman 13.23.07.04

Hanscom Air Force Base, Massachusetts

Our goal is to extend and optimize the performance of the Schottky-array infrared cameras and exploiting their image-information content through signal processing. Research includes the following: (1) experimental work on fabricating and characterizing individual photodiodes and characterizing and testing focal-plane arrays; (2) theoretical studies of internal photoemission in metal/silicide Schottky diodes; (3) studies of algorithms and architectures of image- and signal-processing techniques for enhancement, automatic detection, or tracking using imagery from in-house cameras, the 12-bit resolution from which exceeds commonly available display systems; and (4) hardware implementations using computer-assisted design (CAD) tools and foundry fabrication to obtain working chips for implementing algorithms developed under (3). Experimental research is supported by a full panoply of fabrication, characterization, and electronic test-and-measurement equipment. Extensive dedicated computer facilities include Sun terminal engineering workstations for algorithm exploration, and software and hardware development. Menu-driven software tools, developed in-house, are available for image-processing work on single frames and for processing real-time consecutive frame data taken with a 12-bit recorder.

Semiconductor Guided-Wave Optics

RA Soref 13.23.07.05

Hanscom Air Force Base, Massachusetts

Theoretical and experimental studies of semiconductor integrated-optical devices are needed to improve signal processing and communications at the 0.6–1.1-μm, 1.3-μm, and 1.55-μm optical wavelengths. Although III–V semiconductors are the leaders for such applications, there are economic and scientific reasons to explore silicon-based materials for active and passive waveguide components. Promising new materials include crystalline silicon-germanium and silicon-germanium-carbon alloys. Novel electro-optical effects are anticipated in Si-Ge superlattices and in SiGe/Si or SiGeC/Si multiple quantum wells. Research focuses on electro-optical modulators and switches that use the free-carrier plasma effect, the quantum confined Stark effect, and the Pockels effect in ordered crystals. Advances in device technology will stem from a multidisciplinary approach that employs optical waveguide theory, solid-state theory, metal oxide semiconductor or bipolar device modeling, optical design, and materials science. Some laboratory equipment is available for characterizing electro-optic guided-wave devices.

Oxide and Covalent Thin-Film Materials and Devices

AJ Drehman 13.23.07.06

Hanscom Air Force Base, Massachusetts

Research on the growth of thin-film oxide and covalent materials involves the following: (1) understanding the physics involved with various deposition techniques, including low-energy sputter deposition; (2) studying interface interaction between the film and substrate, the resultant epitaxy, and growth morphology; (3) studying *in situ* growth of multilayer structures and buffer layers; (4) developing new electronic, magnetic, and optical thin-film devices; and (5) developing novel thin-film materials and structures. Available equipment includes two multisource radio frequency (RF) magnetron deposition systems, an RF diode sputter deposition system, several cryostats for low-temperature electronic properties, a dc SQUID magnetometer, and clean room facilities for device patterning. We also have x-ray diffraction, thermal analysis, and scanning electron microscopy for characterization. Current areas of thin-film research include nonlinear optical materials, conducting and magnetic oxides, buffer layers, high-temperature electronic materials, electrical contacts for wide bandgap materials, and the development of improved low-energy deposition techniques.

Preparing and Analyzing Photonic Materials

JJ Larkin 13.23.07.07

Hanscom Air Force Base, Massachusetts

We investigate optical materials that have potential applications in communications and signal processing. We use melt, flux, sol-gel, and hydrothermal techniques to prepare crystalline and glassy materials. In-house research emphasizes photorefractive materials and glasses, in which the constituents have high polarizability. We also use dopants and novel growth techniques to investigate and optimize photorefractive properties. For example, hydrothermally grown sillenite materials based on bismuth oxide have been found to have different optical properties than melt-grown sillenites of the same composition. Equipment for materials preparation includes eight computer-controlled hydrothermal (high-temperature, high-pressure solution growth) autoclaves, Czochralski and flux-growth systems, high-quality glove boxes, and other equipment for sol-gel and metal-organic deposition. Analytical tools include photoluminescence and optical absorption spectroscopy, Fourier-transform infrared spectroscopy, x-ray diffraction, electron microscopy, thermogravimetric analysis, and differential scanning calorimetry.

Semiconductor Crystal Growth and Characterization

DF Bliss 13.23.07.08

Hanscom Air Force Base, Massachusetts

Our crystal growth program encompasses both bulk and thin-film materials, with emphasis on indium phosphide (InP) bulk crystals and III–V semiconductor films deposited epitaxially on InP. Epitaxial deposition utilizes metal-organic chemical vapor deposition, including one designed for atomic layer epitaxy. Several systems are available for bulk crystal growth, including a large high-pressure puller that is currently used for magnetic-field stabilized Kyropoulos and Czochralski growth of 3-inch diameter InP crystals. In-house characterization capabilities consist of resistivity/Hall effect, photoluminescence, wafer depth profiling, near-infrared microscopy, double crystal x-ray diffraction, and electron microscopy.

Resonant Nonlinear Optical Materials for Signal Processing

PR Hemmer 13.23.07.09

Hanscom Air Force Base, Massachusetts

The goal of this research is to apply novel physics concepts to problems in optical image processing and storage, especially for turbulence diagnostics. Resonant systems are chosen because of their inherently fast response. Current emphasis is placed on the use of resonance Raman quantum interference (coherent population trapping) to improve efficiency and reduce laser intensity requirements. Specific research topics include double-Raman lasers, optical phase conjugation in the double-Lambda system, Raman excited spin echoes, optical Raman nuclear magnetic resonance imaging, electromagnetically induced transparency, and inversionless lasing in semiconductor quantum wells. A cw ring dye laser, numerous semiconductor lasers, atomic beams, vapor cells, cryostats, doped crystals, and microwave components are available for this research.

Reference

Hemmer PR, et al: Optics Letters 20: 982, 1995

Coherent Millimeter and Submillimeter Wave Imaging

UHW Lammers 13.23.07.10

Hanscom Air Force Base, Massachusetts

The scattering of metallic and nonmetallic bodies in the microwave through submillimeter wavelength region is relevant to both military and commercial technology. Topics range from radar cross section control, to nondestructive testing, to medical imaging. We are working to improve our knowledge of the scattering mechanism and the optimum utilization of the information contained in the radar signal. Research focuses on the design and implementation of coherent instrumentation radars for monostatic and bistatic imaging of targets. Analytical work in computational electromagnetics addresses penetrable targets, multiple scattering targets, and image enhancement methods. Captive model targets and canonical bodies under investigation can be both metallic and dielectric. High-resolution two- and three-dimensional radar data are fully polarimetric. The ideal candidate should be well versed in electromagnetic scattering theory and have a solid background in the building and use of instrumentation radars.

Fault Modeling for Very Large Scale Integrated Circuits

WH Debany 13.23.06.01

Rome, New York

Research focuses on the problem of bridging the gap between failure mechanisms in very large scale integrated circuits and system-level on-board diagnostics. Circuit technologies are submicron, high-speed, low-power, and/or radiation-hardened. Both analog and digital circuits are also of interest. Defects that occur at the time of manufacture and failures that occur during storage or operation in the field are studied independently, since they have different causes and statistical distributions. We consider any erroneous operation of a device to be a failure, including those as a result of environmental effects such as single-event upsets or overstress. We investigate the relationships between causes of failures and the resulting observable faulty behaviors in the devices. Such causes include hot electrons, dielectric breakdown, and atomic motion from electromigration forming opens and shorts. These causes are investigated using molecular dynamic simulations and surface analysis techniques to determine the role of materials in failure initiation at the component/ interconnect level, and propagation of these component failures to circuit and system levels. Our goals are to (1) improve the yield of complex, low production volume devices; (2) improve the reliability of fielded devices; (3) improve the efficiency of on-board testing strategies; and (4) improve the design of circuits using fundamental material properties.

Index of Research Advisers

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Telephone and Electronic Mail inquiries concerning technical details of specific research opportunities may be made of the Advisers listed below.

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Index of Research Categories

1997 Research Associateship Programs

Albany Research Center
Armed Forces Radiobiology Research Institute
Center for Devices and Radiological Health
Federal Highway Administration/Turner-Fairbank Highway Research Center
Morgantown Energy Technology Center
NASA Ames Research Center
NASA Dryden Flight Research Center
NASA Goddard Space Flight Center
NASA Jet Propulsion Laboratory
NASA Lyndon B Johnson Space Center
NASA John F Kennedy Space Center
NASA Langley Research Center
NASA Lewis Research Center
NASA George C Marshall Space Flight Center
NASA John C Stennis Space Center
National Biological Service
National Institute for Occupational Safety and Health
National Institute of Standards and Technology
National Institutes of Health
National Oceanic and Atmospheric Administration
Naval Command, Control, Ocean Surveillance Center/Research, Development, Test, and Evaluation Division
Naval Medical Research and Development Command
Naval Postgraduate School
Naval Research Laboratory
The Aerospace Corporation
US Air Force Laboratory
US Army Armament Research, Development, and Engineering Center
US Army Edgewood Research, Development, and Engineering Center
US Army Medical Research and Materiel Command
US Army Missile Command
US Army Natick Research, Development, and Engineering Center
US Army Research Laboratories
US Army Research Office
USDA Forest Service
US Environmental Protection Agency
US Geological Survey
Waterways Experiment Station

Research opportunity booklets and application documents for all programs may be obtained by contacting the

Associateship Programs — TJ 2114
National Research Council
2101 Constitution Avenue
Washington, DC 20418
(202) 334-2760

National Research Council
1997 Research Associateship Programs
Alphabetical by Acronym

Organization	*Accepts the Following Applicants*			
	Postdoctoral	Senior	Foreign	Application Deadlines
AERO THE AEROSPACE CORPORATION	Yes	Yes	No	Jan 15/Apr 15/Aug 15
AFRRI ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
ALRC ALBANY RESEARCH CENTER	Yes	Yes (Limited Number)	In special cases, where additional support is available	Jan 15/Apr 15/Aug 15
AMRMC US ARMY MEDICAL RESEARCH AND MATERIEL COMMAND	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
US Army Medical Research Institute of Chemical Defense	Yes	Yes	No	
ARDEC US ARMY ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER	Yes	Yes	No	Jan 15/Apr 15/Aug 15
ARL US ARMY RESEARCH LABORATORY	Yes	Yes	No	Jan 15/Apr 15/Aug 15

Organization	*Accepts the Following Applicants*			
	Postdoctoral	Senior	Foreign	Application Deadlines
ARO US ARMY RESEARCH OFFICE	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
CDRH CENTER FOR DEVICES AND RADIOLOGICAL HEALTH	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
EPA US ENVIRONMENTAL PROTECTION AGENCY	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
ERDEC US ARMY EDGEWOOD RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
FHWA FEDERAL HIGHWAY ADMINISTRATION	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
METC MORGANTOWN ENERGY TECHNOLOGY CENTER	Yes	Yes	No	Jan 15/Apr 15/Aug 15
MICOM US ARMY MISSILE COMMAND	Yes	Yes	Legal Permanent Residents Only	Jan 15/Apr 15/Aug 15

Organization	*Accepts the Following Applicants*			
	Postdoctoral	Senior	Foreign	Application Deadlines
NASA — <u>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION</u>				
ARC — AMES RESEARCH CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
DFRC — DRYDEN FLIGHT RESEARCH CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
GSFC — GODDARD SPACE FLIGHT CENTER Goddard Institute for Space Studies Wallops Flight Facility	Yes	Yes	In Basic Science Areas	Jan 15/Apr 15/Aug 15
JPL — JET PROPULSION LABORATORY	Yes	Yes	In Basic Science Areas	Jan 15/Apr 15/Aug 15
JSC — LYNDON B. JOHNSON SPACE CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
KSC — JOHN F. KENNEDY SPACE CENTER	Yes	Yes	In Basic Science Areas	Jan 15/Apr 15/Aug 15
LaRC — LANGLEY RESEARCH CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
LeRC — LEWIS RESEARCH CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
MSFC — GEORGE C. MARSHALL SPACE FLIGHT CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
SSC — JOHN C. STENNIS SPACE CENTER	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
NBS NATIONAL BIOLOGICAL SERVICE	Yes	Yes	No	Jan 15/Apr 15/Aug 15
NIH NATIONAL INSTITUTES OF HEALTH	Yes	Yes	Seniors only; Otherwise, Legal Permanent Residents	Jan 15/Apr 15/Aug 15

Organization	*Accepts the Following Applicants*			
	Postdoctoral	Senior	Foreign	Application Deadlines
NIOSH NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH	Yes	Yes (Limited Number)	Yes	Jan 15/Apr 15/Aug 15
NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY	Yes	No	No	Jan 15
NMRDC NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	Yes	Yes	Yes	Jan 15
NPS NAVAL POSTGRADUATE SCHOOL	Yes	Yes	In Selected Areas	Jan 15/Apr 15/Aug 15
NRaD NAVAL COMMAND, CONTROL, AND OCEAN SURVEILLANCE CENTER; RESEARCH, DEVELOPMENT, TEST, AND EVALUATION DIVISION	Yes	Yes	No	Jan 15/Apr 15/Aug 15
NRDEC US ARMY NATICK RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER	Yes	Yes	Yes	Jan 15/Apr 15/Aug 15
NRL NAVAL RESEARCH LABORATORY	Yes	No	No	Jan 15/Apr 15

Organization	*Accepts the Following Applicants*			
	Postdoctoral	Senior	Foreign	Application Deadlines
USAF US AIR FORCE LABORATORIES				
Armstrong Laboratory	Yes	Yes	Regular: No	Jan 15/Apr 15/Aug 15
Phillips Laboratory	Yes	Yes	(except in	Jan 15/Apr 15/Aug 15
Rome Laboratory	Yes	Yes	special cases)	Jan 15/Apr 15/Aug 15
Wright Laboratory	Yes	Yes	Senior: Yes	Jan 15/Apr 15/Aug 15
USDA/FS USDA FOREST SERVICE	Yes	No	No	Jan 15/Apr 15/Aug 15
USGS US GEOLOGICAL SURVEY	Yes	No	No	Jan 15
WES WATERWAYS EXPERIMENT STATION	Yes	Yes	In certain cases, with approval by director	Jan 15/Apr 15/Aug 15