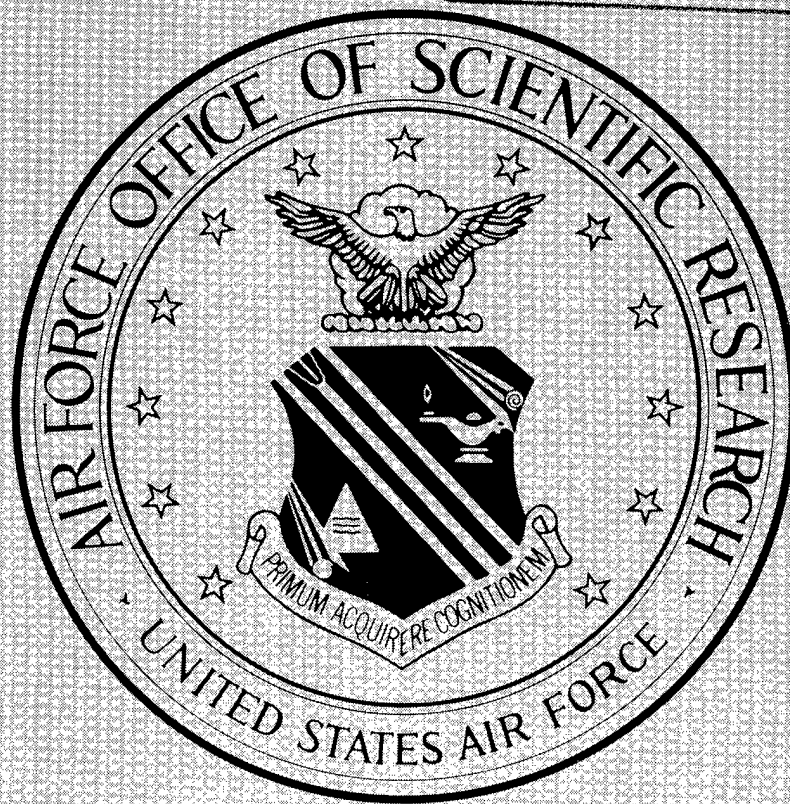


1993 RESEARCH HIGHLIGHTS

Air Force Office of Scientific Research
Bolling AFB DC 20332-0001

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Preface

With this issue of *Research Highlights*, AFOSR begins an annual calendar publication which is based on our monthly collection of significant achievements and accomplishments. This edition contains only a selection of AFOSR's many research successes in 1992, but they represent how we fulfill our basic research mission. The highlights provide brief descriptions of research accomplishments, examples of technology transfer and technology insertion, and notable peer recognition through awards and honors. Their purpose is to provide Air Force, DOD, government, and private sector officials interested in science and technology management with brief accounts illustrating AFOSR support of Air Force and DOD missions and the national posture in technology.

Basic research has always been of great importance to the Air Force in maintaining technological superiority and is even more crucial in the post-Cold War world. General "Hap" Arnold's words in 1944 that "the first essential of Air Power is pre-eminence in research" ring as true today as they did in the waning days of World War II. Some of the research highlighted here will find its way into currently deployed Air Force systems; some will not reach maturity until we enter the 21st century. The *Research Highlights* also illustrate our contributions to the major DOD thrusts and critical technologies and to the national goal of technology competitiveness. The diverse and wide-ranging disciplines of our scientific directorates are represented here and their common denominator is quality research. In consonance with its motto, "Building Partnerships With Excellence and Relevance," AFOSR continues to fulfill its important role as a technology transition broker: fostering the discovery of new theoretical or experimental knowledge while ensuring the transition of research results to support user needs and to create new user opportunities. With this charter, AFOSR will provide the Nation with the required depth and scope of options for new and advanced technologies to meet future challenges.

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Directorate of Aerospace Sciences

Turbomachinery Research Aimed at Preventing Stall and Surge

A three-year AFOSR research program at MIT has successfully demonstrated the feasibility of identifying and actively controlling a traveling wave precursor to prevent rotating stall and surge in gas turbine engines. This knowledge is now being used at Wright Laboratory to investigate similar flow physics in their high-speed engine facilities. The successful identification of this stall precursor in a high-speed environment represents the critical bridge to transitioning this technology to an actual Air Force development program. Several steps are underway to make this happen: (1) the Compressor Research Facility at Wright Laboratory is testing a candidate ATF engine which will take advantage of MIT's model to help achieve stall avoidance, (2) an Air Force Institute of Technology masters degree student will be conducting research at the Compressor Aerodynamics Research Laboratory by implementing and extending MIT's theory and software to be used on a single-stage high-speed compressor component, and (3) Aeronautical Systems Center has also become very interested in the theory of active control to help optimize engine schedules and performance maps to achieve greater fuel savings in new production gas turbine engines. The unique capabilities and coupling of MIT and Wright Laboratory has positioned this research for transitioning.

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Super-maneuverable Aircraft: In the Making

AFOSR recently sponsored a workshop on super-maneuverability at Lehigh University (Pa). The workshop addressed major, unresolved issues associated with agile aircraft and missiles operating in the high-angle-of-attack flow regime. More than 80 participants attended, including leading industry and academic experts; tri-service, NASA, and DARPA representatives; and two European scientists participating in AFOSR's Window-On-Science program.

DARPA and NASA outlined basic research contributions for near-term applications involving high-alpha technology programs such as the X-29, X-31, and High Angle Research Vehicle (Navy F/A-18) demonstration vehicles. A white paper capping key research issues will be sent to the R&D community.

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High-Enthalpy Hypersonic Shock Tunnel Comes On-Line

Researchers at the California Institute of Technology's Graduate Aeronautics Laboratory have begun preliminary testing in their new, high-enthalpy, free-piston shock tunnel named T5. (Enthalpy is directly proportional to the temperature of the flow.) T5 was designed and built by CALTECH researchers under AFOSR sponsorship.

Currently, no way exists to design hypersonic Air Force vehicles without full-scale construction and costly flight test programs. The tunnel facility will allow designers to test proposed vehicle configurations prior to actual construction of flight vehicles.

The tunnel is the largest facility of its kind in the United States and is the only facility capable of duplicating the high-temperature aerothermodynamic flight environments experienced by actual hypersonic flight vehicles. Pressures in excess of 20,000 pounds per square inch and temperatures in excess of 10,000 degrees Kelvin can be simultaneously achieved in T5.

AFOSR-sponsored research will investigate the synergistic effects of high-speed viscous phenomena, compressible turbulence structures, and finite-rate chemistry processes present in such flows over hypersonic flight vehicles.

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Air Force Basic Research Supports Peacekeeper and Minuteman Missile Programs

Dr. C.T. Liu of the Air Force's Phillips Laboratory Propulsion Directorate at Edwards AFB developed a nonlinear crack tip model which successfully predicted the onset of crack growth in the Peacekeeper missile's first stage propellant. Dr. Liu is the principal investigator in the "Fracture Mechanics and Service Life Prediction" program, conducted and managed by Phillips Laboratory's Propulsion Directorate. This program focuses on fracture behavior in solid rocket motors and is developing advanced technologies for the prediction of crack growth behavior in these materials.

Program achievements include advanced crack growth prediction methodologies, based on nonlinear fracture mechanics, and experimental techniques for the evaluation of three-dimensional effects in cracked motor grain geometries. These methods and techniques are currently being used to evaluate the propellants in the Peacekeeper, Minuteman and other missile systems. These techniques are also being used to determine the extent and effect of damage on crack growth behavior in the Minuteman's first and third stage propellants.

These techniques may be used in the future to determine the stress distribution along the front of surface cracks in Titan IV propellant grain. The results of the studies may also provide information

that can be used to determine extension of the service life of rocket motors and guide the development of accept or reject criteria for propellants in Minuteman, Titan and other missile systems.

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Better Engines and Aircraft Through Realistic Modeling of Turbulent Flows

A Princeton University research team has developed a revolutionary approach to the problem of modeling turbulent flows. Turbulence plays a variety of important roles in the flight environment. It helps achieve good mixing of fuel and air in combustors, but it creates undesirable drag on flight vehicle surfaces. Models of turbulence currently used in computational fluid dynamics applications do not work very well for such complex problems as turbine blade heat transfer, aero-optics and flow separation on flight vehicle surfaces.

The new approach developed by Professors Steven A. Orszag and Victor Yakhot is based on a novel adaptation of renormalization group (RG) methods originally used to describe the behavior of critical point phenomena by Nobel laureate Dr. Kenneth Wilson. Their research has produced useful engineering turbulence models which are free of the highly dissipative behavior characteristic of traditional models. As a result, flow behavior near surfaces predicted by the RG method is much more realistic. For example, flow separation and reattachment, including heat transfer, has been accurately modeled in all cases tested to date. Unlike its predecessors, the new formulation captures large scale unsteady flow features such as vortex shedding, and it predicts the overall drag on complex bodies within a few percent. The best news is that the new method can be easily incorporated into the kinetic energy-dissipation methods now in widespread use by the aerospace industry. The method has already been adopted by Fluent, Inc., which holds nearly a third of the worldwide market in computational fluid dynamics software. The Air Force Wright Laboratories are exploring the method for possible application to heat transfer and combustion in gas turbine engines.

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Directorate of Chemistry and Materials Science

Aircraft Structural Composite Design Improvements Inspired by Nature

Advanced composite materials have been identified as one of DOD's critical technologies, with significant present and projected application to Air Force weapons systems. The AFOSR Biomimetics task conducted at Wright Laboratory Materials Directorate, Wright Patterson AFB, has identified promising and unusual composite design features occurring in the exoskeleton of the common bessbeetle. Because stress concentrations at fastener holes are prevalent in aircraft, drill-hole strength tests are critical to the aerospace industry as criteria for material qualification. Tensile tests of ± 30 degree laminates incorporating continuous fibers molded around hole contours, in analogy to features of the beetle, indicate a 40 percent improvement of the ultimate load and improved cracking resistance in comparison to plies incorporating drilled holes.

Dr. Frederick L. Hedberg
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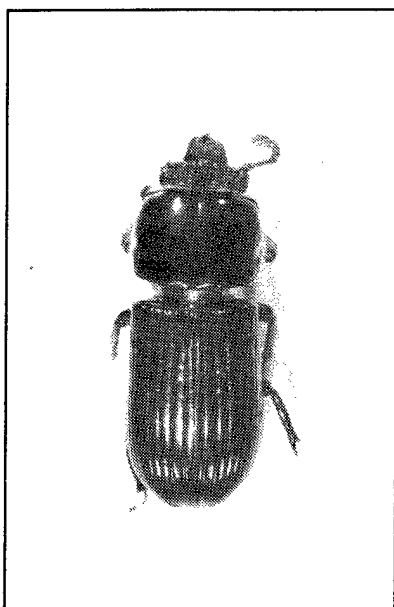


Figure 1a.
The common bessbeetle.

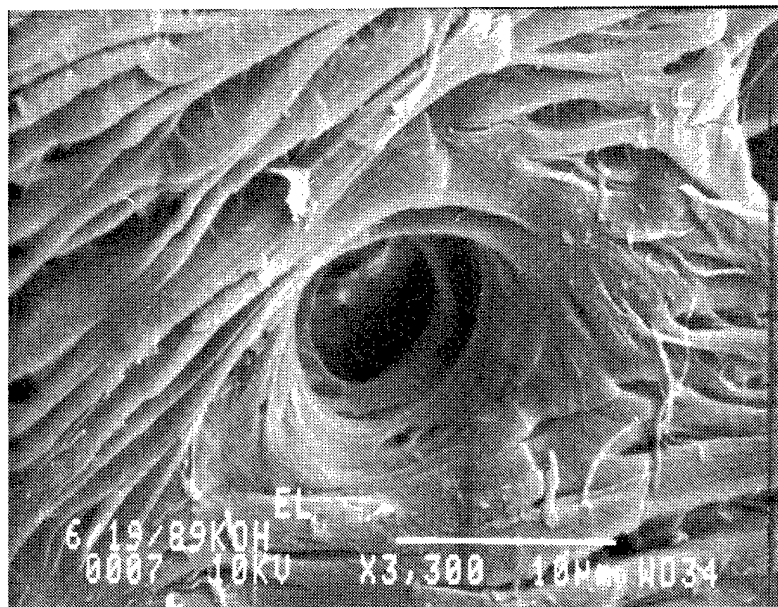


Figure 1b. A Scanning Electron Microscopy photograph of a pore hole in the bessbeetle exoskeleton illustrates molded laminated composite design.

Chemical Modeling Theory Improves Materials Performance, Cuts Production Costs

Professor Michael Dewar is renowned as the discoverer of the semiempirical approach to chemical modeling theory. His research in this area has been primarily supported for many years by AFOSR's Directorate of Chemistry and Materials Sciences, first at the University of Texas and subsequently at the University of Florida. Professor Dewar has expansively acknowledged this support in his autobiography: *A Semiempirical Life*.

His research objective was to provide chemists with computational procedures for theoretical prediction of chemical reactions and reaction mechanisms which could be used as practical adjuncts to experimental procedures.

The result of his work is a revolutionary as well as evolutionary predictive methodology for chemists.

A measure of its success is its widespread use. According to a recent survey, Professor Dewar's computational procedures account for 40 percent of the money spent on chemical computing by chemical and pharmaceutical companies.

Air Force materials benefits from Professor Dewar's research are twofold: molecular structure and properties predictions which translate into aerospace materials with improved performance, and optimized synthesis processes which translate into lower production costs.

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Chemistry Now Visible at Atomic Level

University of Pittsburgh Professor John T. Yates, Jr. is receiving notable scientific community recognition for his pioneering research on surface imaging. Through development of his new technique, Electron Spin Desorption Ion Angular Distribution (ESDIAD), researchers can now detect and follow the motion of atoms and molecules on regular surfaces. The knowledge of such motion provides the basis for building many important technologies including semiconductor processing, industrial catalysis and lubrication.

Until now, the scientific community has only been able to infer atomic motion indirectly. In fact, only during the past seven years have atomic scale surface structures been directly imaged using the revolutionary scanning probe techniques, but atom motion is invisible to these new tools.

With ESDIAD, Professor Yates has demonstrated how to follow the motion of atoms and molecules on regular surfaces. "This is really the beginning of the visualization of chemical

reactions," he says, "where you can see molecule A beginning to snuggle up to Molecule B and interact with it." With better insight into how atoms and molecules behave, this knowledge can be used to produce low wear lubricated surfaces to reduce the friction and wear of moving parts creating longer life and reduced maintenance costs. Recent publication (Royal Society of Chemistry) of his comprehensive survey of this chemistry research area is recognition for creating a new, emerging field of science. Articles in the 13 March 1992 issue of *Science* magazine and the 30 March 1992 issue of *Chemical and Engineering News* highlight his work and describe techniques, application and major researchers (many of whom receive AFOSR sponsorship.)

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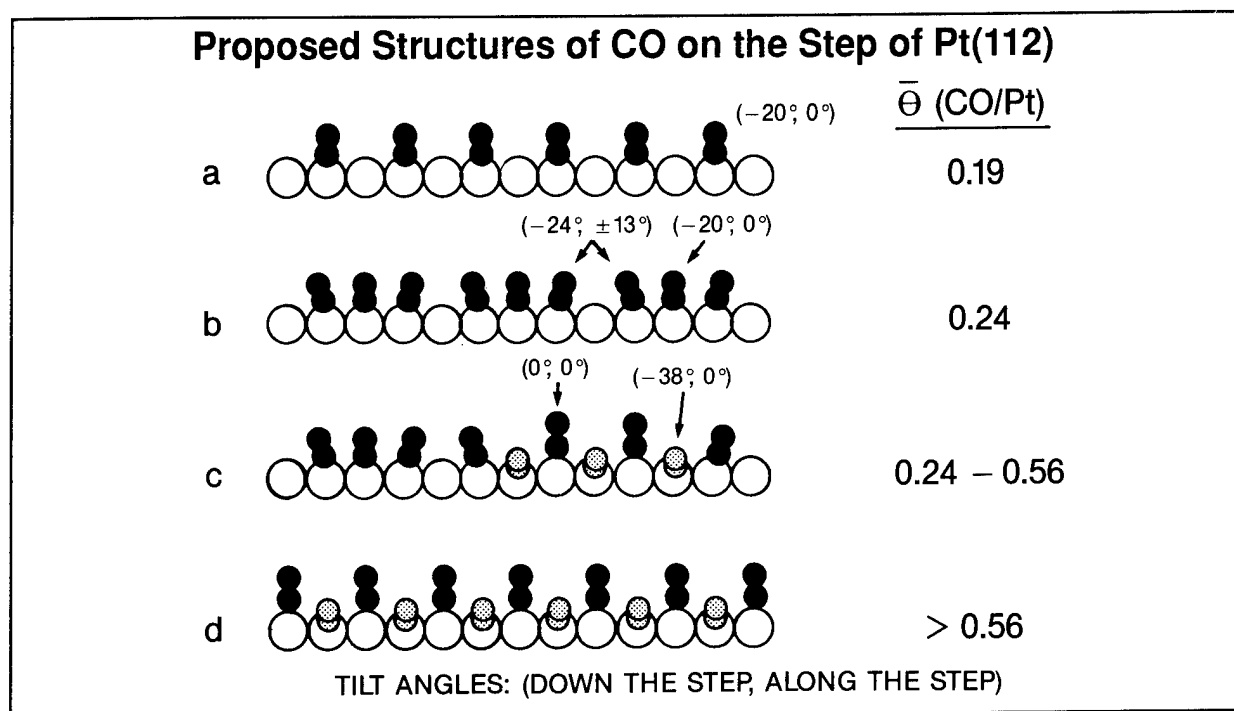


Figure 2. A view of CO molecules on a Platinum (Pt)(112) surface (Pt atoms are represented as open circles): At low coverage (a) isolated CO molecules are adsorbed on every other Pt site. As the coverage increases (b, c) other sites fill, causing some CO molecules (black) to tilt left and right, while other molecules (gray) remain untilted laterally. When all sites are filled (d), lateral tilting is no longer allowed due to steric hindrance. This causes the molecules to tilt backwards and forwards as they sterically repel each other. (Source: Professor John T. Yates, Jr., University of Pittsburgh)

Innovative Processing of Advanced Structural Materials

A joint Air Force Office of Scientific Research and Office of Naval Research workshop on Innovative Processing of Intermetallic Materials and Metal Matrix Composites was held from 18 to 20 May 1992. The workshop was attended by 30 scientists including three Wright Laboratory basic research task managers and 14 AFOSR contractors and grantees.

The workshop brought together researchers from a wide variety of disciplines who are using innovative and diverse techniques for processing advanced structural materials based on metal-matrix composites and intermetallics. These applications in advanced aircraft and spacecraft are prime candidates for future turbine engines, propulsion systems and skin materials for hypersonic flight vehicles.

Attendees exchanged recent results and identified future directions for processing research. These directions included: laser processing, mechanical alloying, solidification, vapor deposition, electrodeposition, and spray atomization. Materials of interest included aluminides, silicides and beryllides.

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New Laser Aimed to Machine Parts for Aircraft Engines

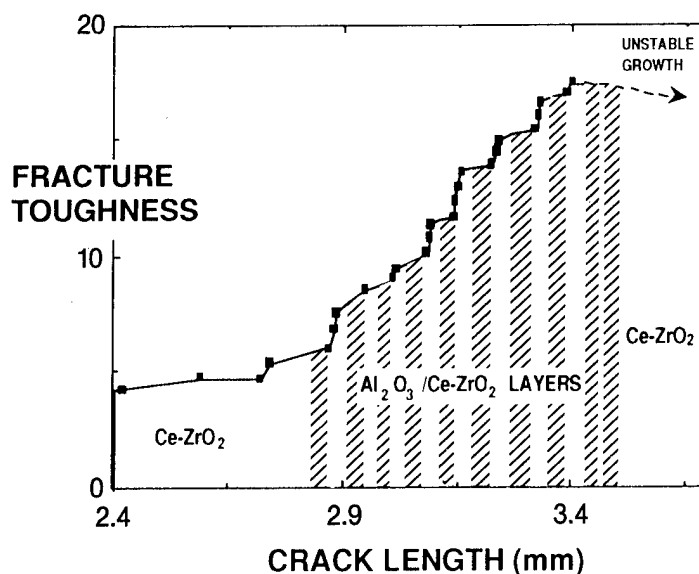
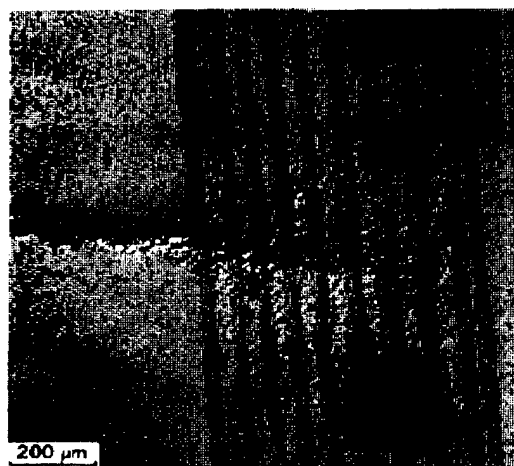
The jet engines of the new Air Force F-22 advanced tactical fighter may contain metal components that will be machined using a new laser system developed by United Technologies Corporation (UTC) under an AFOSR-sponsored program at the Phillips Laboratory. UTC has filed a request for an exclusive license for the photolytic iodine laser technology. This technology was developed under the direction of Dr. L. A. Schlie from the Phillips Laboratory. This laser, which operates in the infrared region of the spectrum (1.3 micrometers) possesses excellent beam quality, and would provide significant enhancements over commercial laser welders which operate at 10.6 micrometers.

UTC and the Phillips Laboratory are also in the final stages of negotiating a Cooperative Research and Development Agreement for an efficient, 1 kilowatt photolytic iodine laser to be used in a state-of-the-art laser machine processor. This computer-controlled "Smart Laser Processing Machine" would be capable of performing metal-machining and processing tasks on jet engine parts that are currently considered impossible. Applications for the automobile industry and production of heavy machinery are also being considered.

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Improved Ceramic Composite for Advanced Tactical Fighter Engines

Significant improvements in the engine performance of Air Force advanced tactical fighters requires turbine structures which can reliably operate at temperatures much higher than existing ceramic materials. Ceramics research by Dr. David B. Marshall, supported by AFOSR at Rockwell



- Transformation zone enlarged in layered region
- Fracture toughness increases as crack grows: R-curve
- Toughening also observed for cracks growing parallel to layers

Figure 3. The figure illustrates the results of a fracture toughness test on a new layered ceramic structure. The crack induced stress promotes a volume-increasing transformation in the Ce-ZrO₂ layer opposing the crack propagation.

International, has produced a laminar composite ceramic material which has significantly higher strength and toughness than its separate components. Dr. Marshall demonstrated that the presence of barrier layers in materials greatly increases their toughness and ability to deflect cracks. This advance signals the development of a new class of reliable, high temperature structural ceramic materials for aerospace applications.

Dr. Marshall has a patent pending for the idea of introducing very thin barrier layers in a periodic laminar bi-ceramic structure. In recognition of his work, he received the prestigious Fulrath Award from the American Ceramic Society, given annually to the American researcher who has made the most significant contributions to the science of ceramic materials.

Technology transfer of this material will require more efficient processing techniques to generate laminar materials for test and evaluation. In a parallel AFOSR-supported research program, Dr. Marshall is working with Professor Fred Lange of the University of California (a recently elected member of the National Academy of Engineering) to prepare a more efficient technique for preparing multi-layer ceramic structures. In addition to the long range payoff for structural ceramics, this technique could lead to the rapid commercialization of multi-layer ceramic materials for high-value, electro-optic device technologies.

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Biological Corrosion in Electronic Packaging

AFOSR-sponsored research discovered the first evidence that biological corrosion must be considered in the otherwise inert organic polymers used in electronic packaging. The research, carried out under the direction of Professor Ralph Mitchell at Harvard University, revealed that electronic-grade polyimides are susceptible to colonization by microorganisms. The microorganisms have the potential to cause corrosion either by directly metabolizing the polyimides or producing corrosive acidic chemicals by metabolizing chemical species adsorbed on the polyimides.

Polyimides and other organic polymers are being used in advanced Air Force and commercial packaging for conformal coatings and resistive thin films in multilayer circuitry. These polymers were chosen because of their low dielectric constants and good resistance to environmental factors such as chemical corrosion, moisture and thermo-oxidated degradation. However, biological corrosion was not considered when polyimides were selected and now must be accounted for. Once this phenomenon has been fully understood, counteractive measures can be planned to prevent failures in Air Force electronics systems caused by biological corrosion. The results of this research may also lead to novel waste disposal methods for the ever increasing amounts of polyimides used for structural composites. Polyimides were chosen for structural applications in part because of their resistance to environmental degradation.

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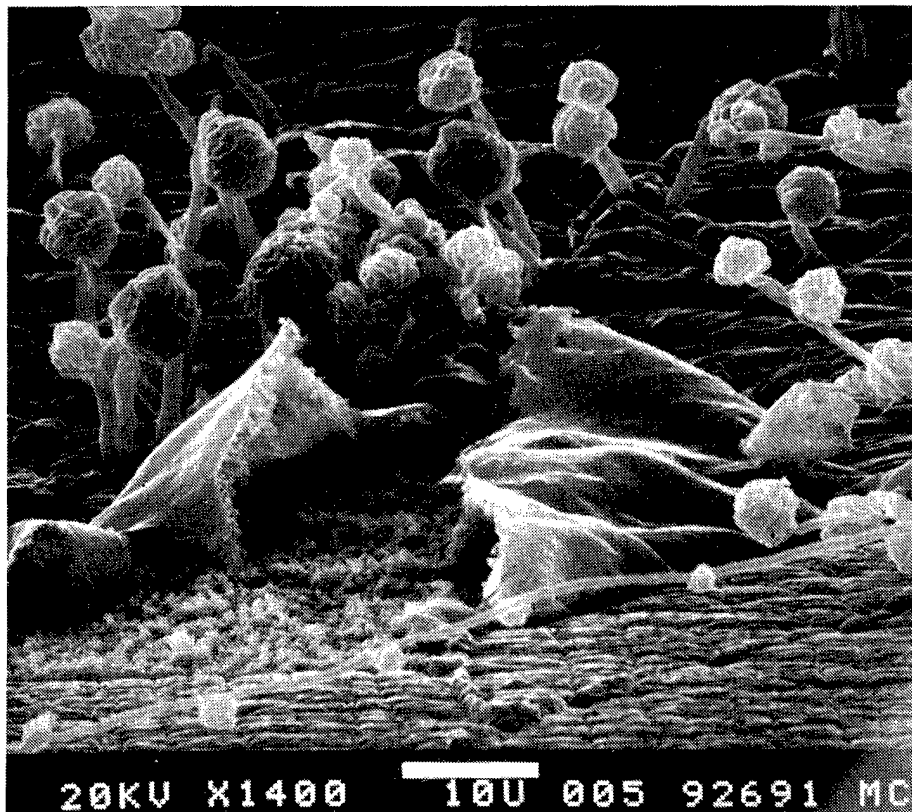


Figure 4.
Scanning Electron
Microscopy photo-
graph of electronic
packaging polyimide
film undergoing
colonization by
microbes.

Pioneering Material "Polyceram" Offers Revolution in Camera Lens Design

Professor Donald R. Uhlmann of the University of Arizona is a pioneer researcher for a new class of hybrid materials named polycerams. The polycerams are currently being tested for use in structures, optics, and fuel-resistant insulation. Polycerams, as the name suggests, consist of polymers (e.g., plastic or rubber) and ceramics (glass or porcelain). At the molecular level, polycerams appear as three-dimensional networks of bricks joined together by rubber bands. Blending the materials improves structural integrity and compressibility. In his research, Professor Uhlmann has succeeded in tailoring the properties of a very complex polyceram which includes polyethylene and urethane, labeled STU. By adjusting the chemical ratios of STU polycerams containing 60 percent polymers, he was able to vary the refractive index of the polyceram over a range of 1.48 to 1.70. This represents a tremendous increase in the refractive index and will have a major impact on the field of optics, particularly in making new materials for lenses. Applications include use in cameras and aero-optic communications systems. The lenses could be planar and would not have to be ground. They could also be made extremely small since minimal physical processing would be required. Smaller lenses would be more efficient in constructing new, more miniaturized fiber optic systems.

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Directorate of Physics and Electronics

Workshop Launches AFOSR Optical Memory Program

One of the most promising concepts for ultra-high density storage of optical information is called persistent spectral hole-burning. AFOSR's Directorate of Physics and Electronics hosted an inaugural workshop in February 1992 at Boeing's Center for High Technology for approximately 12 spectroscopists and device scientists from industry, academia and government (including Rome Laboratory's Dr. Philip Hemmer) laboratories.

They discussed relative efficiencies of photon-atom interaction mechanisms, and outlined implementation techniques for writing, reading and erasing persistent spectral holes in various rare earth-doped crystals.

These techniques applied to optical memories promise a three order of magnitude expansion of optical storage density (10^{10} bits per cm^2 or 10^{13} bits per cm^3), with readout rates at a terabit per second. Applications extend from multi-process input/output buffering for high speed parallel computers to extremely high bandwidth database correlators for signal identification.

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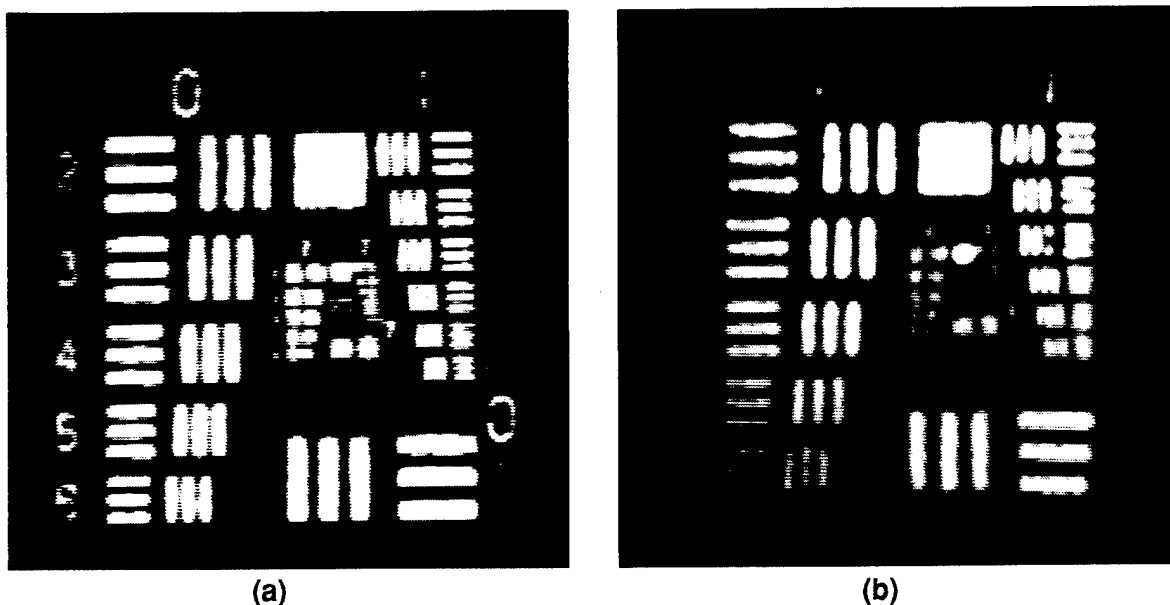


Figure 5. This figure is an example of the spectral hole-burning concept discussed at the workshop. Fidelity and spatial resolution are demonstrated in proof-of-principle experiments comparing the input (write) and output (read) data fields for a two-dimensional, optically addressed memory that uses persistent spectral hole-burning technology. (a) Input data image (USAF resolution chart); (b) Read-out image retrieved optically from the memory.

Breakthrough Made in Wavelength Tunable Infrared Laser Crystal Technology

Wright Laboratory has succeeded in demonstrating for the first time that it is possible to synthesize large germanium phosphide (ZnGeP_2) laser crystals for revolutionary, broadly tunable infrared laser systems. This feat was realized via growth optimization guided by world-class, in-house characterization capability.

The synthesized crystals are nearly an order of magnitude superior than the current state-of-the-art material in laser efficiency and thermal conductivity, and have far superior mechanical properties. In direct comparison with current systems as to high average power, the crystals delivered over one million watts of peak power and set a new world record of 18 percent overall conversion efficiency.

Due to efforts by Drs. Ohmer, Hopkins and Hemenger of Wright Laboratory's Electromagnetics Materials Development Group, the program has also been an ideal example of the marriage between basic research and exploratory development from its inception. On the basis of the outstanding research results, Wright Laboratory is planning new FY93 advanced development and manufacturing science programs to transition research rapidly to application.

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Advanced Laser Design Software Package Developed

Professor Anthony E. Siegman, an AFOSR principal investigator at Stanford University, and his research group have developed an advanced software package known as PARAXIA for laser and optical beam calculations. This new software package consists of four interactive programs which allow laser and optical system designers to use desktop computers to calculate laser resonator and optical beam line propagation behavior. In addition, it allows designers to modify design inputs and to view program outputs using graphic inputs and visualization methods. These procedures previously required batch runs on Cray-class computers.

Details on the development of the PARAXIA package, along with the several research projects based on it, are the major components of a recent article titled "Laser Beam and Resonator Calculations Using Desktop Computers" published by Professor Siegman's group. PARAXIA packages, originally distributed to many major government agencies, industrial laboratories and universities by the Stanford University Software Distribution Center, can now be obtained through Genesee Optics Software, Inc., in Rochester, N.Y.

A fellow of the Optical Society of America, he has received their R.W. Wood prize for his invention of the unstable resonator, and the Frederick Ives Medal, the highest award recognizing outstanding contributions to the field of optics. He is also a fellow of the National Academy of Engineering. He

served as chairman of the Basic Sciences Panel of the Air Force Scientific Advisory Board, and is currently an advisor to the Phillips Laboratory Phased Integrated Laser Optics Technology Project program. (PILOT is designed to integrate a very large number of small semiconductor lasers to behave together as a single high power laser.) "Development of this software would not have been possible without the sustained support of our research in lasers and especially in laser resonators and laser beam properties provided by AFOSR over the years," Professor Siegman said. "Use of this package in industrial and government laboratories will strengthen U.S. industrial productivity and defense capability."

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High Power Microwave Tube Research to Improve Electromagnetic Warfare

The Air Force has awarded a substantial design contract based on AFOSR-sponsored research on high power microwave tubes at Hughes Research Laboratories in Malibu, Calif. Dr. Jennifer Butler, a staff scientist at Hughes, received a contract from the Air Force's Phillips Laboratory to develop a new high power microwave (HPM) source. The Hughes device concept, called a PASOTRON for "Plasma-assisted Slow-wave Oscillator," offers megawatts of microwave power in pulses that last significant fractions of a second in a range of frequencies around a gigahertz. If successful, this device concept holds the promise of numerous Air Force applications in the realms

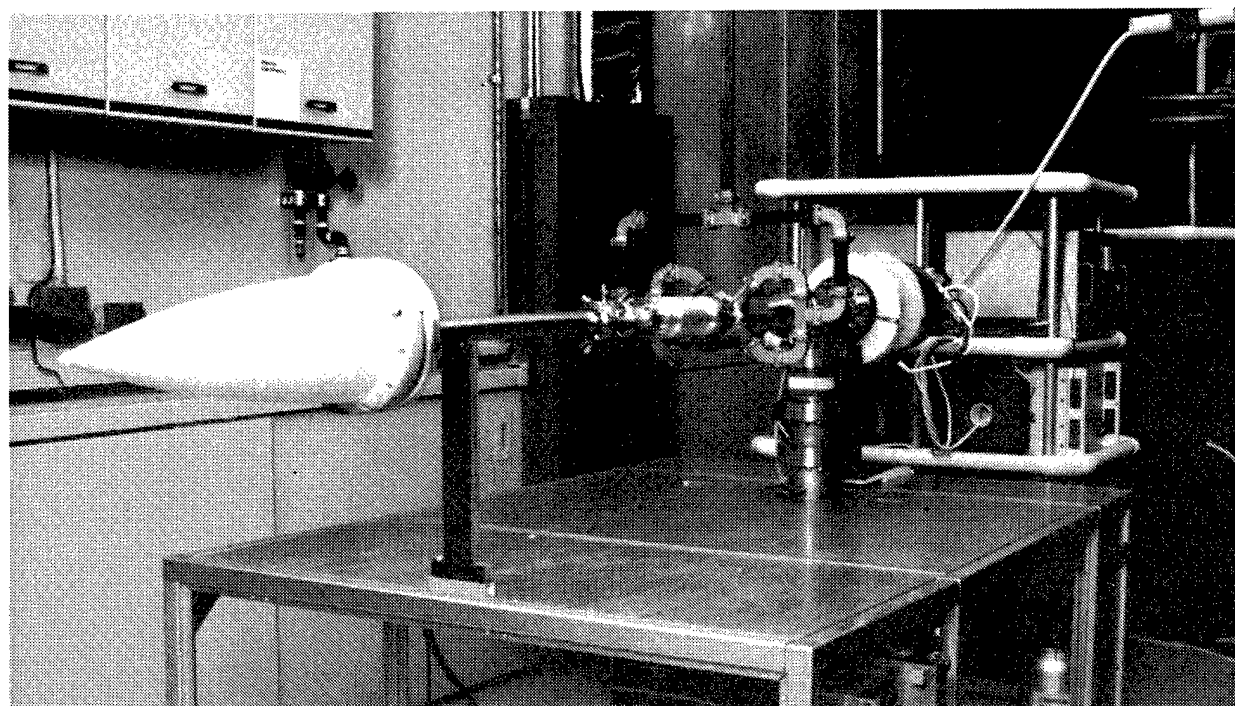


Figure 6. The PASOTRON high energy microwave test apparatus.

of electromagnetic warfare and advanced weapons systems. Additional features of the device include simple design, a revolutionary new electron-beam source, and the complete lack of heavy, bulky magnets which plague alternative HPM schemes. The current Hughes PASOTRON is the direct outgrowth of a family of plasma-filled microwave sources for which AFOSR has provided research funding since 1986.

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Optical Interconnects May Enable Sensor Fusion by Smart Pixels

A group of researchers sponsored by AFOSR at the University of California at San Diego has developed optoelectronic devices that facilitate communication routing between silicon electronic circuits. The four researchers, Dr. Sadik Esener, Dr. Harry Wieder, Dr. Charles Tu and Ms. Chi Fan, developed a new surface normal optical modulator that operates at an optical wavelength of 1060 nanometers (nm), more than 200 nm longer than previous versions. Creating a longer wavelength modulator structure is important because the gallium arsenide (GaAs) substrates on which most optoelectronic modulators are fabricated strongly absorb optical wavelengths shorter than 1000 nm. By "flip-chip" bonding the GaAs wafers on which the electronic modulators are grown and fabricated to electronics-carrying silicon wafers, complete process and interconnect

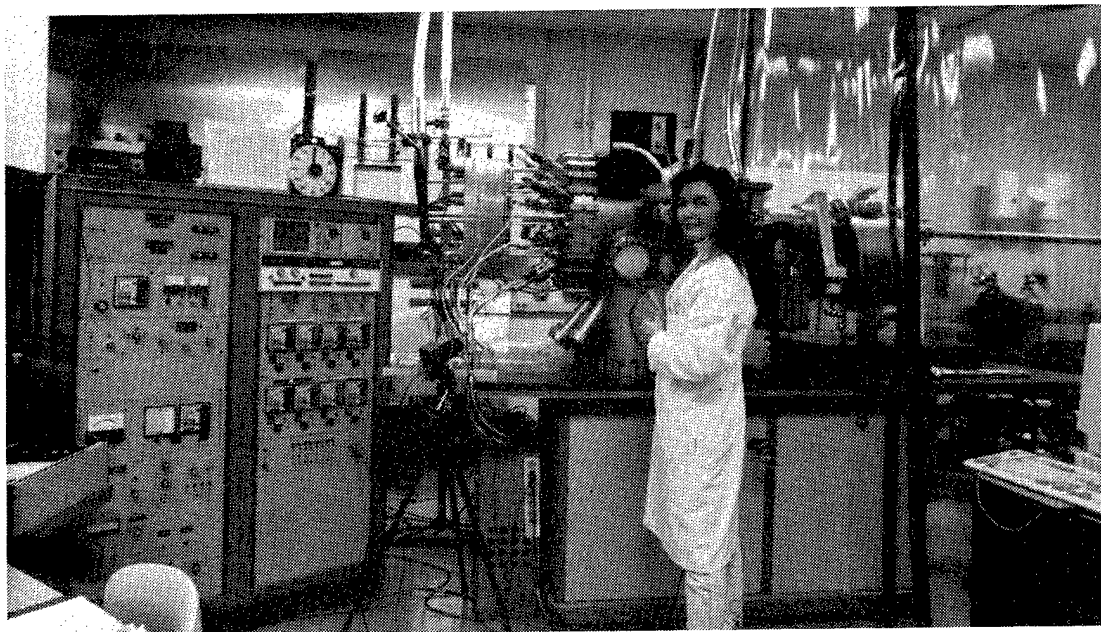


Figure 7. Ms. Chi Fan, a doctoral candidate in Electrical Engineering at the University of California, San Diego is pictured with the Molecular Beam Epitaxy high vacuum deposition chamber. Stepped-composition strain-buffering layers are grown in this chamber which allow GaInAsP films to adhere to optically transmissive GaAs substrates.

smart pixel modules can be built. The optical beams carrying data and program information to the optical modulators and electronic processors at each smart pixel can now pass through the optoelectronic substrate material, substantially increasing flexibility in architectural design. The AFOSR researchers devised a major breakthrough in materials growth to circumvent a lattice constant mismatch problem which would have been deleterious to material stability and device performance. Arrays of smart pixels in cascaded modules will enable parallel processing computational architectures to accelerate functions such as aircraft sensor fusion and control or image processing for target recognition and tracking.

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New Interferometer Provides Greater Accuracy in Geodesy and Navigation

A new type of interferometer has been developed based on the pioneering research work of Professor Steven Chu and his group at Stanford University. The new interferometer could lead to the development of highly sensitive accelerometers and rotation sensors for use in Air Force navigation, guidance and control systems. Unlike older interferometers which use the interference between beams of light to compute optical wavelengths, the version developed by Chu and his research group makes use of the wave nature of matter and observes the interference between atomic beams. Since the atomic beams have much shorter wavelengths, more sensitive measurements can be made. When used as an accelerometer, the interferometer can measure the acceleration of an atom by gravity to a precision of three parts in one hundred million. In the next generation device, it should be possible to exceed one part in one hundred billion.

The new interferometer may also improve the measurement of vertical land mass movement for earthquake prediction, the height of ocean levels for global warming studies, and local changes in the acceleration of gravity for oil exploration. In combination with the ranging capabilities of the global positioning system (GPS), the new interferometer will make it possible to measure phenomena such as water table changes or the underground flow of lava near a volcano.

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Directorate of Life and Environmental Sciences

New Radar Technique Measures Lighting Potential

AFOSR-sponsored researchers from New Mexico Tech have developed a revolutionary new technique for detecting charge buildup in clouds. The technique, first tested in August 1992 at the Kennedy Space Center, uses a circularly polarized radar signal and advanced signal processing to detect ice crystal alignment in clouds. In theory, the ice crystals should become aligned in response to charge buildup, just like static electricity makes your hair stand on end.

The first hint that this technique might work came two years ago during post analysis of data taken during New Mexico thunderstorms. The conclusive proof came last summer when real-time displays of the cross correlation between the co-polar and cross-polar returns vividly showed increased particle alignment prior to each natural lightning discharge.

This technique promises to enable weather forecasters to provide much better warnings for both natural and rocket/aircraft triggered lightning. For the first time, they will be able to remotely sense the charge buildup even before the first natural lightning strike.

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New Technique Discovered for Rapid Diagnosis and Therapeutic Cell Destruction

AFOSR supported Air Force scientists, Drs. Jonathan Kiel, Jill Parker, and John Bruno of the Directed Energy Division, USAF Armstrong Laboratory, have discovered a transferable genic agent that will label bacterial and human cells for diagnostic and therapeutic purposes.

The expression of this gene in living cells stimulates the production and release of growth factors. Because growth factors encourage rapid multiplication of labeled cells, standard microbiological tests for cell identification can be accomplished much sooner than if the cells are allowed to grow at natural rates, e.g., one hour versus twenty-four hours. Moreover, the products of this expressed gene generate luminescence (free radicals) when irradiated by microwaves causing host cells to be more sensitive to antibiotics as well as heat and light.

Therefore, this new genic agent can be used as a label to very rapidly diagnose disease and infection

and also for therapeutic destruction of both tumor cells and infectious agents. An invention disclosure has been prepared and submitted to the U.S. patent office.

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Neural Networks Aid Engineering Design

Adaptive Resonance Theory (ART), a neural network devised to understand human learning and pattern recognition, helps Boeing Aircraft Company solve the problem of design reuse.

The neural network, created by Drs. Stephen Grossberg and Gail Carpenter at Boston University with support from AFOSR, explains how humans easily learn to distinguish a vast number of different objects without constant correction and without forgetting much of what was previously learned. Moreover, the huge number of objects humans easily recognize does not seriously slow down their recognition of new objects.

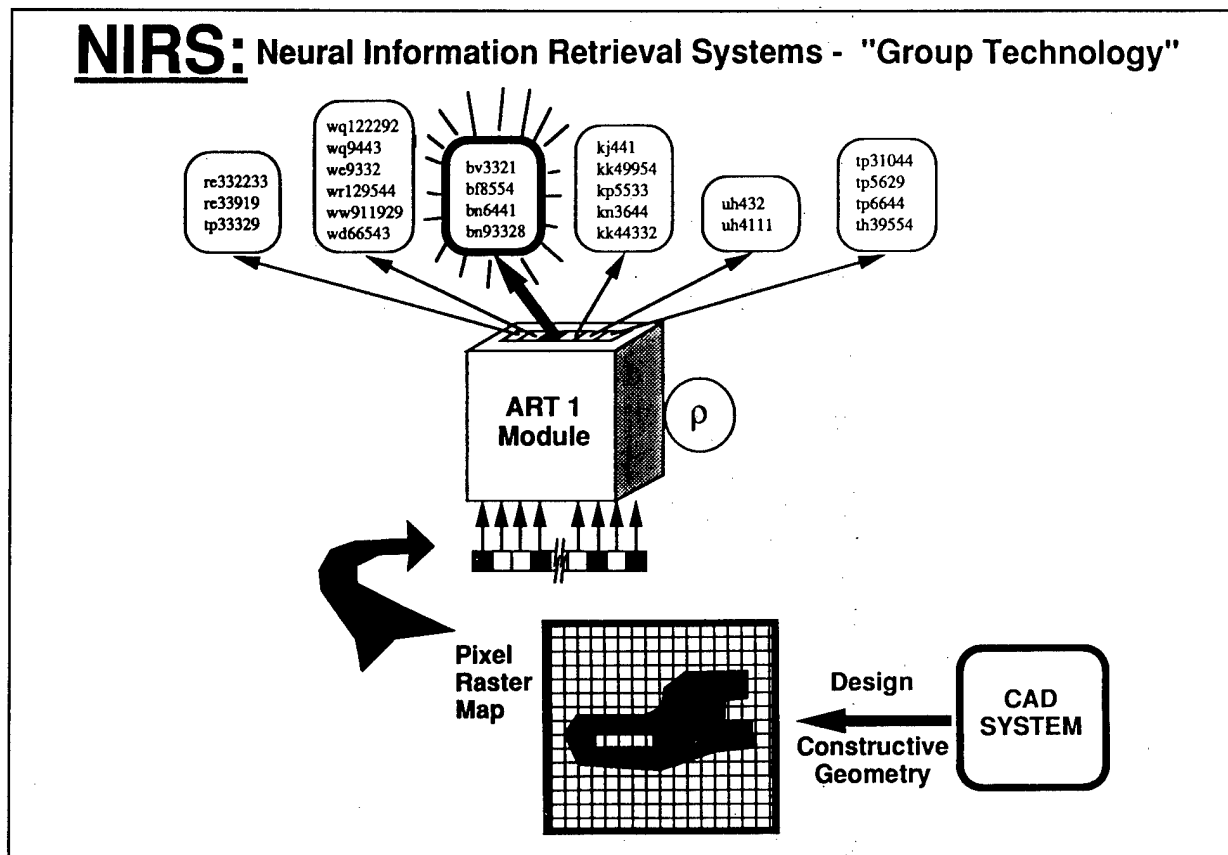


Figure 8. The Neural Information System creates groups of similar parts based on similarities in their construction. When designers create a new part, the system can tell them whether similar parts have been made in the past. Considerable time and money can be saved when similar parts are found in an inventory that might include millions of previous designs.

The problem of engineering reuse requires comparing the parts for a new system with available parts. If new parts are found available, considerable time and money can be saved in design, fabrication and maintenance of the new system. Searching for new parts can be most tedious for systems like aircraft that include millions of available parts.

Boeing's prototype solution embeds ART in a software system that represents old and new parts in a way that lets a computer calculate how similar they might be. Using ART provides the system human-like features of continuous learning and fast recognition. The neural network software can be interrogated during the design of new parts and quickly tell the designer whether a similar part is available. New parts can be added continuously. Thousands of parts are used in prototype and, based on initial success, many thousands more will be added.

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Rocket Fuel Waste Disposal Method Improved

A scientific and engineering research team at the Air Force Civil Engineering Support Agency, Tyndall AFB, Fla., has discovered a microbe which can convert the toxic wastes generated by solid fuel rocket engines into harmless byproducts. This microbe, isolated from a complex mixture of microorganisms, attacks the perchlorate ions found in the waste products. This AFOSR-sponsored research program is expected to result in a new technology for treating solid propellant waste streams and thus reduce life cycle costs for a number of Air Force rocket systems. Captain Mark Smith, Project Officer for the Environics Division, Air Force Civil Engineering Support Agency, headed the team that made this discovery and received the Air Force Systems Command Science and Technology Achievement Award for his participation.

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Detecting Pre-Lightning Sparks in Florida Thunderstorms

While conducting AFOSR-sponsored research at Kennedy Space Center, Dr. Ewen Thompson of the University of Florida discovered a small electrical discharge phenomenon that often precedes lightning. The primary purpose of Dr. Thompson's research was to study the signal characteristics of lightning, but to his surprise, he also detected short, bi-polar "sparks" in clouds several minutes before the lightning bolts. The discovery of this phenomenon may eventually enable weather forecasters to measure the lightning potential of specific clouds, resulting in more accurate forecasts. It would be of tremendous advantage to forecasters at space and missile launch sites,

reducing the chance of lightning strikes on valuable space payloads, particularly in the lightning ridden area of Cape Canaveral.

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Figure 9.
Dr. Paul Krehbiel (left)
of New Mexico Tech.
and Dr. Ewen Thomson
(right) of the University
of Florida inspect one of
Dr. Thomson's VHF
lightning detectors.
Using an array of five
such detectors, Dr.
Thomson discovered
the existence of pre-
lightning sparks
emanating from
charged clouds.



New System Developed to Predict Solar Activity

Systematic observation of the evolution of solar active regions is the key to modeling and predicting solar disturbances that severely impact USAF and DOD space operations and planning. Such modeling requires as input highly accurate measurements of active region flow and magnetic fields of the sun. AFOSR researchers have developed a new filter system which makes this accurate data available for the first time. The new system consists of a tunable, narrow band filter with an image stabilization system. It has been successfully used to obtain extensive data on the development of solar active regions.

Dr. Stephen L. Keil of the Phillips Laboratory Geophysics Directorate, Solar Physics Branch and National Research Council Fellows Drs. Luigi Smaldone and Gianna Cauzzi, developed this new observing technique that enables the tracking of the three-dimensional evolution of solar active regions. The research which led to the new technique was part of the Solar Terrestrial Physics intramural program of AFOSR's Space Sciences Project.

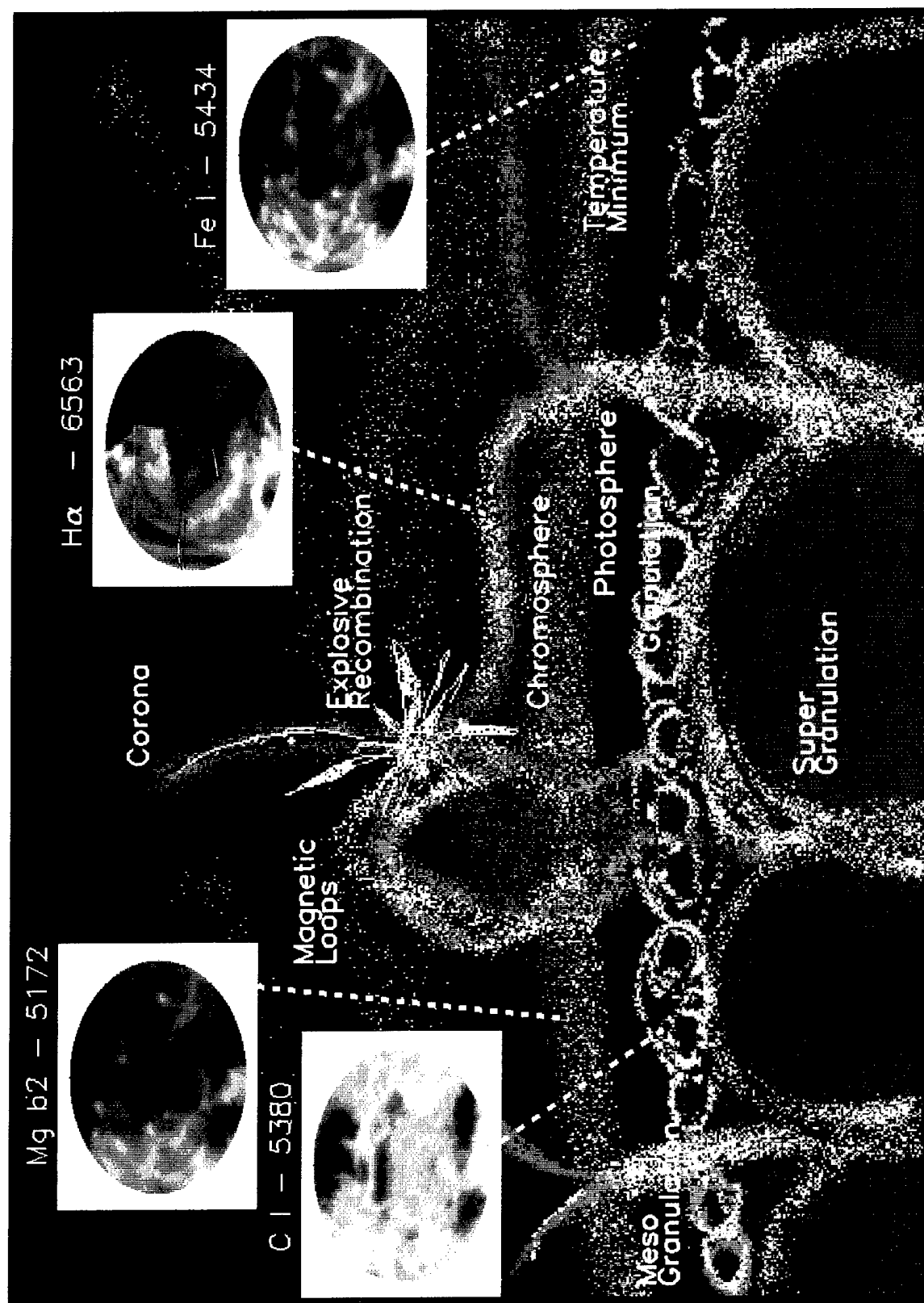


Figure 10. Observing Solar Activity with a Narrowband Filter.

Throughout the current maximum in solar activity, the new capability will be used in conjunction with a powerful array of other measurements to form a complete picture of solar activity for the first time. The improved solar measurements and the modeling techniques developed from them are crucial to the solar prediction capability of the Air Force Space Forecast Center. The capability is critical for accurate and timely forecasts of space weather and terrestrial atmospheric conditions that affect DOD space assets and C3I activities.

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Improved Training Manuals Through Software-Assisted Text Editing

Scientists have known for some time that the clarity of a written text can affect its comprehensibility, but formal definitions of clarity were lacking until recently. Dr. Bruce Britton, an AFOSR-sponsored researcher at the University of Georgia, demonstrated that some problems with clarity are due to "cognitive gaps," defined as poor overlap in the surface meaning of phrases that refer to the same thing. Using this definition, Dr. Britton found that cognitive gaps could be inferentially filled in by readers, but this ability differed and resulted in poor comprehension by some. In continuing his research on reading ability, Britton developed software tools that could process text, detect the cognitive gaps and make suggestions for improvement.

Dr. Britton's research has shown that when cognitive gaps are removed, reading comprehension scores improve. In addition, scientific analysis of current training and education texts reveals a considerable number of gaps (as many as two-thirds of all sentences). The software tools developed by Britton should help Air Force technical writers and editors greatly improve the material used in training courses.

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Tactile Stimulant Decreases Pilot Reaction Time

Professor Randal Nelson of the University of Tennessee, Memphis, studied sensory-motor integration and how it is modulated as a function of attention and motor set. Results from his experiments during the past year indicated that visually-guided movements are performed more quickly when visual targets are presented in conjunction with a vibratory signal to the hand that is to be moved. Under the least complicated experimental conditions where the target was moved in predictable directions, vibrations applied to the subject's palm increased the speed of response by 20 percent. In the more complex and realistic situation of a target moving in unpredictable directions to

unknown locations, vibration increased the speed of response by 10 percent. Employing these vibratory signals in an operational setting such as a dogfight could serve to increase the pilot's situational awareness, a crucial factor in aerial combat. It could also help decrease the pilot or weapon systems officer's reaction time to maneuver the aircraft or fire weapons.

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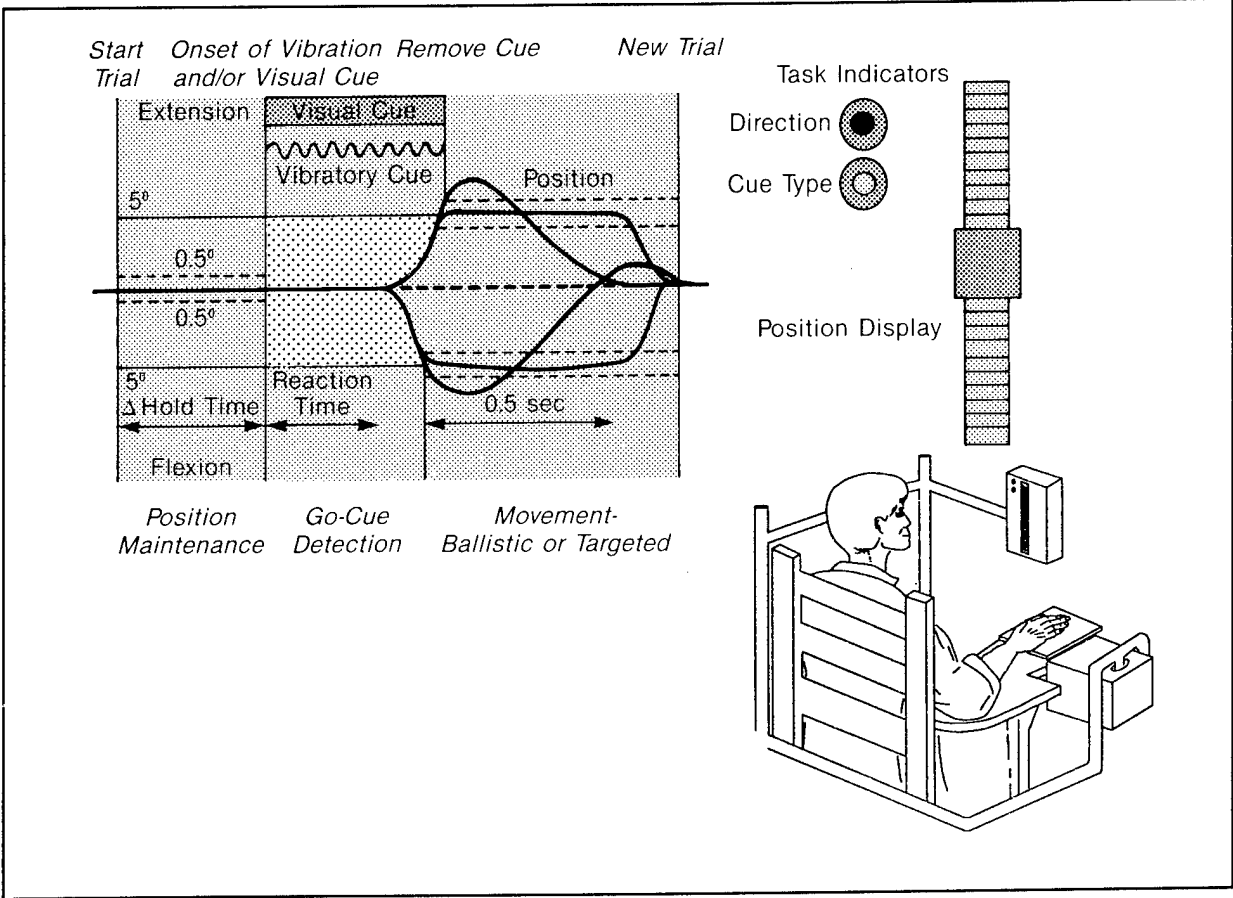


Figure 11. Vibration applied to a person's hand increases the speed of response to a visual target by 20%. The left side of the figure diagrams the experimental conditions. The right side shows the human subject in the experimental arrangement.

Directorate of Mathematics and Computer Sciences

Math Research Tool Transitions for Widespread DOD, Industry Applications

Professor Layne Watson of Virginia Tech has pioneered the development of probability-one homotopy algorithms for solving large, coupled sets of highly nonlinear equations. The problem of solving such sets of equations is pervasive in DOD engineering design applications. He has also implemented these algorithms in a state-of-the art suit of programs called HOMPAC, which is in the public domain. HOMPAC is transitioning into a wide range of current industrial applications of great interest to DOD.

Recent, successful transitions:

- Harris Corporation is using this methodology in their approach to designing robust feedback controllers for a variety of DOD applications including the Air Force's Inexpensive Flight Experiment (INFLEX) for deployable space structures (Philips Laboratory).
- AT&T: HOMPAC has changed the way circuit simulation is done at AT&T. Effective simulation for the design of electronic circuits, especially integrated circuits, requires robust numerical methods for the solution of large systems of highly nonlinear equations. AT&T's simulation work has demonstrated the unsurpassed robustness of probability-one homotopy methods for such problems.
- General Motors: HOMPAC has had a major influence on how solid modeling is done. Their CAD/CAM system GMSOLID uses homotopy methods.
- NASA: Homotopy methods have succeeded in some variable geometry truss design problems for NASA that were untouchable by other methods. These methods are proving to be very useful in vision problems where motion and structure can be characterized as solutions of a system of multivariate polynomial equations.

(Discussion of Homotopy Methods: In the nonlinear sets of equations commonly occurring in the applications, one usually has little information about potential approximate solutions, and this is where homotopy methods shine. The idea of a homotopy method is simple. To solve a set of nonlinear equations, first find a simpler set of nonlinear equations known to be solvable, and then continuously deform this system of equations into the original set of equations and track the evolution of the zeros. The main research challenge was finding such homotopy methods with good global convergence properties.)

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New Theory Describing Interconnection Networks Pays Off

Moving data between processors in massively parallel machines can be a daunting and complex task. The ability to do it rapidly and correctly directly affects both the cost of building the machines, and the speed with which they can perform calculations.

An interconnection network theory developed by Dr. Issac Scherson of the University of California (Irvine) under AFOSR sponsorship was recently used to analyze the design of back plane wiring in massively parallel machines developed by the MasPar Computer Corporation. Dr. Scherson was able to demonstrate that the wiring used to connect the various processors was redundant by a factor of two.

The company now has two beneficial options. It may choose to reduce the complexity of the back plane by reducing the redundant wiring, thereby driving down system cost and increasing system reliability. On the other hand, it may choose to retain the wiring but reuse it by increasing the communication path widths between the processors. The company estimates that this latter option, again guided by the theory, will increase the speed of their machines by a factor of eight with no measurable increase in the complexity of the existing back plane.

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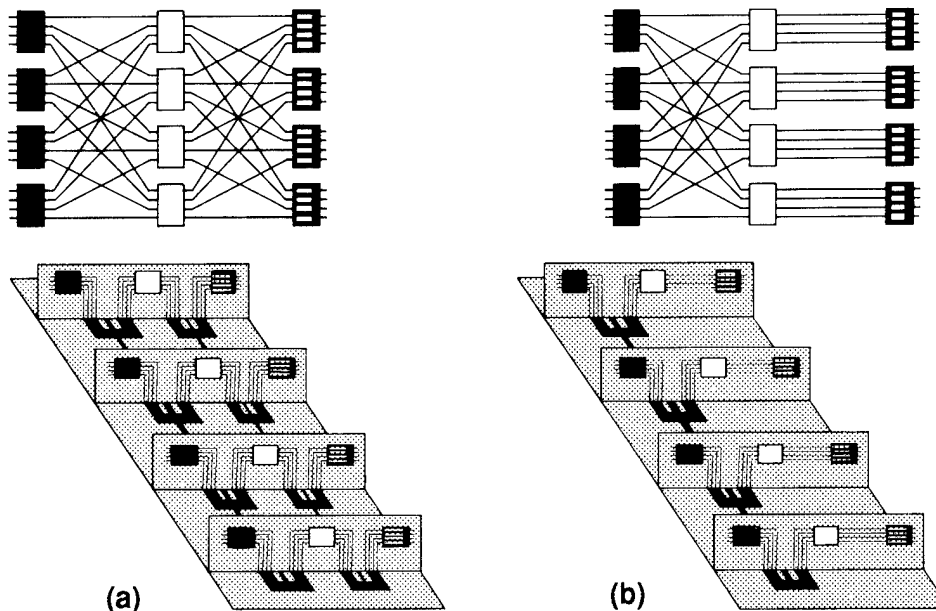


Figure 12. (a) Shows the wiring for the MasPar MP-1 global router network. The blocks are hyperbutterfly switches. Professor Scherson demonstrated that the network shown in (b) is equivalent to the network in (a). This allowed the elimination of the second stage of permutation wiring. By eliminating this wiring, MasPar has been able to speed up routing by a factor of eight for subsequent computer models.

New Optimization Tools Will Improve AMC's Transportation Scheduling Ability

New mathematical modeling tools that will allow Air Mobility Command (AMC) to more realistically schedule transportation routes were identified during a recent joint AFOSR/AMC workshop held at HQ AMC, Scott AFB, Ill. In response to recent DOD restructuring activities, AMC now schedules all Air Force tankers. Other responsibilities, ranging from operating the Defense Courier Service to worldwide cargo routing, are also rapidly undergoing change due to new mission requirements.

The workshop allowed AMC pilots and staff to discuss their transportation requirements, problems and current operational models with AFOSR-sponsored academic and industry researchers representing optimization, computer science and artificial intelligence disciplines. Alternative solutions based on mathematical advances were proposed to allow improvements in scheduling and routing.

The computational models needed to support the AMC mission represent some of the largest and most challenging research opportunities to test new ideas and direct new research efforts. (Recent examples of these challenges include the modeling efforts performed for critical and time-constrained studies needed for Desert Storm mobilization efforts; planning exercises for casualty evacuation during a European conflict; and route optimization models to reconfigure European and Pacific route structures for periodic AMC flights.) New research efforts to address these types of challenges will be developed to include programs involving probabilistic information in optimization models, more efficient techniques for determining integer solutions and integrating optimization and simulation models.

Previous AFOSR support during the past five years enabled the Military Airlift Command (AMC's predecessor) to replace its \$9 million KORBX computer system with three workstations and a new optimization code (OBI) at a cost of \$150 thousand and achieve better computational performance.

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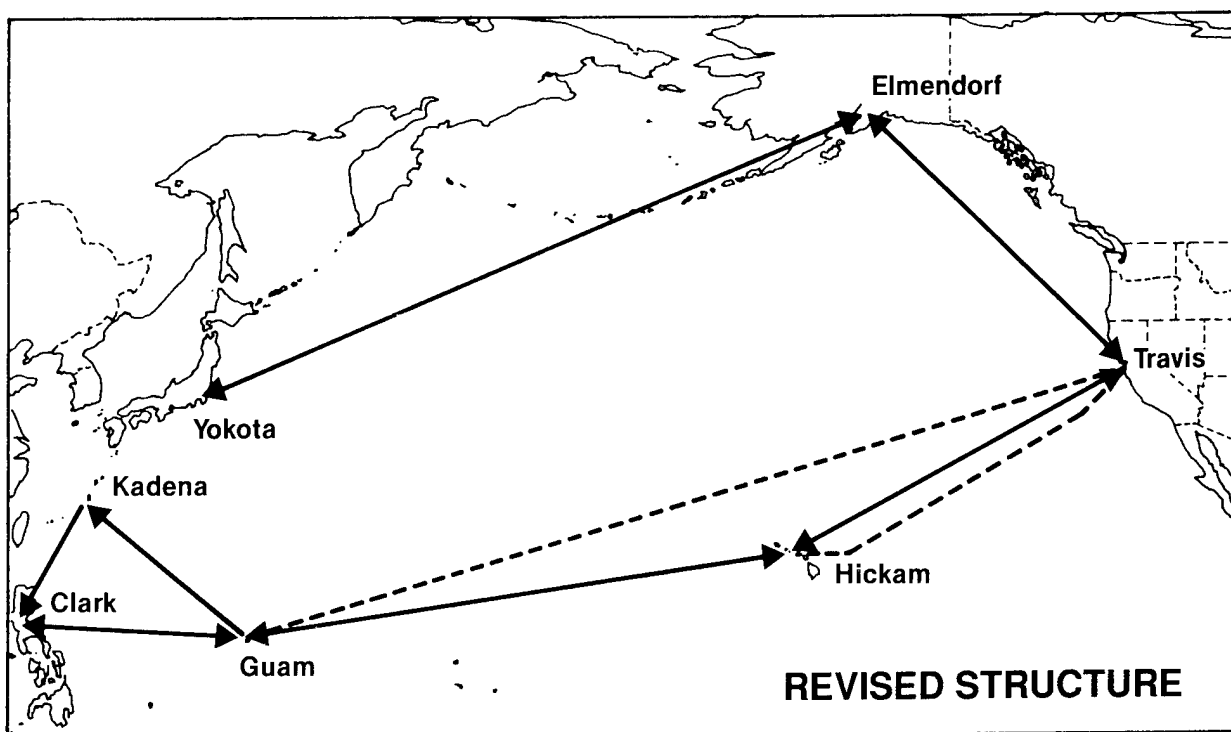
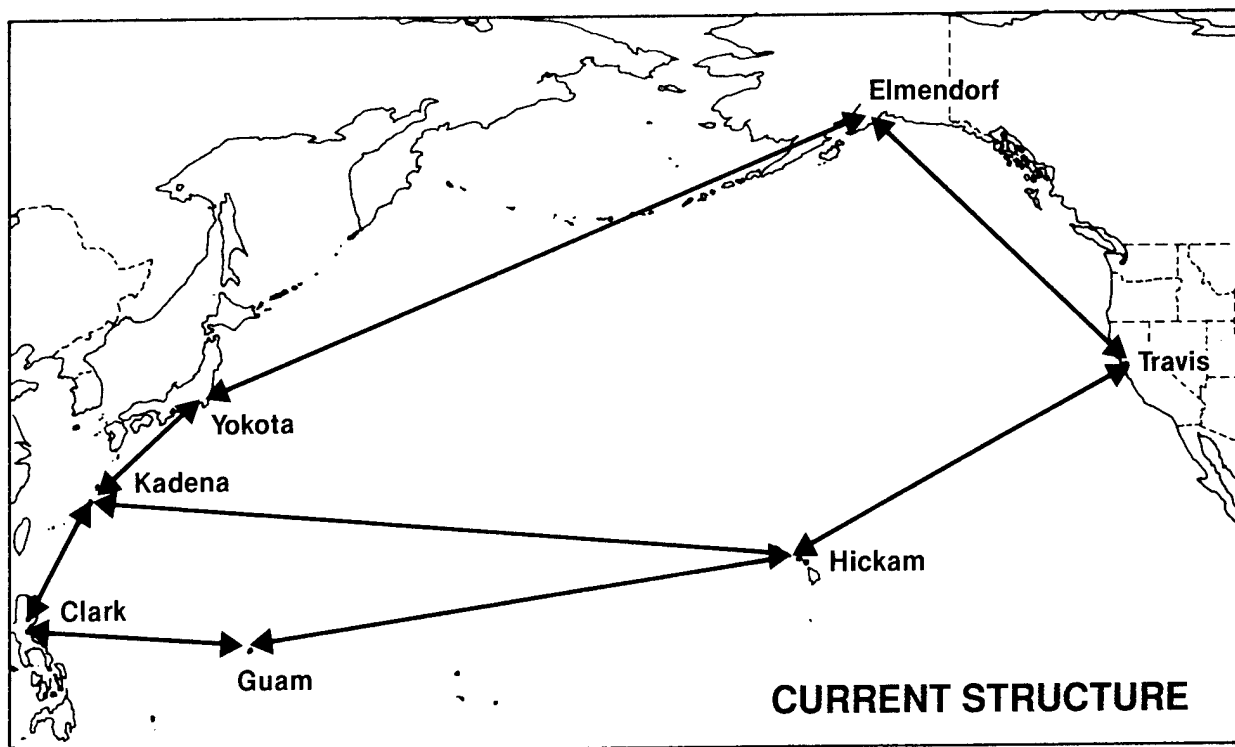


Figure 13. A comparison of the original structure and the revised one which resulted from the optimization of the Pacific routes.

Optimal Design and Control Enhances Aerospace Vehicle Performance

A multidisciplinary AFOSR-sponsored research team, led by Professors J.A. Burns, E.M. Cliff and M.D. Gunzberger at Virginia Polytechnic Institute (VPI), has developed rigorous and efficient new mathematical methods and computational algorithms for the optimization-based design and control of nonlinear distributed parameter systems. This new methodology presents some exciting new opportunities for enhancing the performance and survivability of aerospace vehicles while keeping within cost constraints.

The research team is currently collaborating with a group of engineers at the Air Force's Arnold Engineering Development Center (AEDC) to apply their work to optimal aerodynamic shape design problems in order to improve fidelity and lower the cost of jet-engine testing. One aspect of these efforts requires the design of a forebody simulator (FBS)—a part of the test apparatus that simulates the effects of an aircraft's forward fuselage on the engine-inlet flow. Early experiments on the FBS problem at VPI are very encouraging. The new approach to computing sensitivities has proven highly accurate and at least ten times faster than standard methods. The key to the team's success is the observation that sensitivity equation approaches, adjoint schemes and mixed methods often used in system identification algorithms may be extended and refined specifically for shape optimization and optimal design.

Forebody simulator →

→ F-15 engine inlet model mounted upright

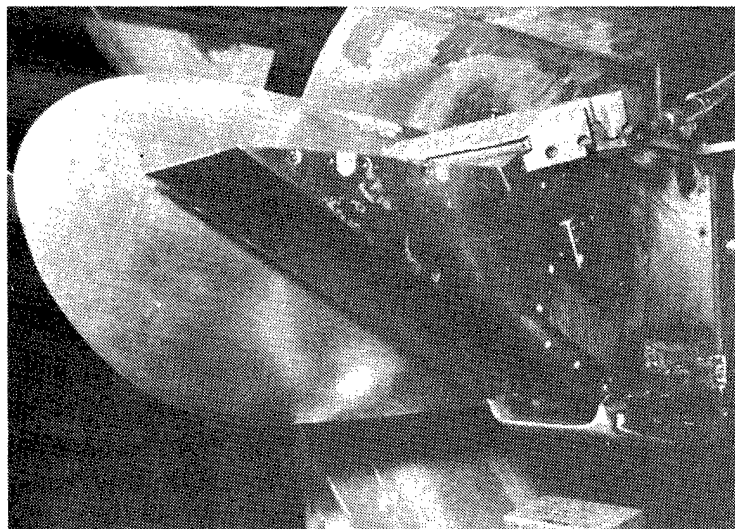
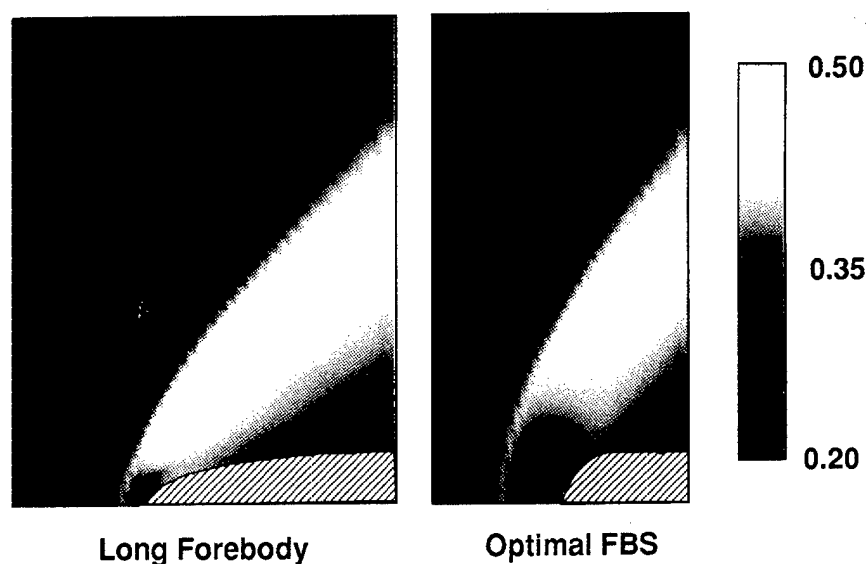


Figure 14a. F-15 engine inlet model mounted upright with a forebody simulator. The forebody simulator is at the left of the picture and the F-15 engine inlet to the right.

Figure 14b. Sample calculation of the X-momentum contours in the optimal forebody design using the new sensitivity equation approach. The figure on the left shows half of the cross section of a full forebody; the figure on the right shows the forebody which "best" meets the flow conditions at the inlet reference plane (right boundaries in the two figures) subject to the constraint that its length be half the original length.



While many aspects of this methodology are still under investigation, applications to several problems of direct interest to the Air Force have been initiated. In addition to the AEDC forebody simulator problem, these include: the active control of wing elements for flutter suppression; transonic drag reduction, as in the mission adaptive wing; and control of heat transfer from hot gases to internal engine components.

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Method Improves Data in Wind Tunnel Tests

Two AFOSR principal investigators, Dr. Norman Malmuth of Rockwell Science Center in Los Angeles and Dr. Julian Cole of the Mathematics Department of Rensselaer Polytechnic Institute, have provided the Air Force's Arnold Engineering and Development Center with a rational means of accounting for the unavoidable wall interference effects that accompany model tests. Transonic flight conditions (Mach .7 to .9) prevail on the majority of long cruises for many Air Force platforms and for most civilian jet fleets. Even a modest reduction in the drag coefficient would, in the aggregate, save considerable resources. However, the prediction of drag coefficients requires a description of free-flight pressure fields and the wind tunnel walls, even the slotted AEDC tunnel, greatly complicate the calculation. The transonic test regime, in contrast to the subsonic or supersonic, presents the greatest challenge to filtering out tunnel wall effects. Test envelopes can occur for which the flow in the wind tunnel does not even qualitatively resemble that in free-flight. These "rogue" conditions are due entirely to the existence of the tunnel walls.

In tests corresponding to slender airframes, the AFOSR researchers were able to determine that an area rule holds in which the interference of the complete airframe can be obtained from its equivalent body of revolution. Tests with the slender airframes and large wall heights exhibited an asymptotic, triple-deck structure consisting of a cross-flow dominated zone near the model, a weakly perturbed free-field middle zone and a linear multipole far field. The zonal decomposition identified by Malmuth and Cole clarifies the nature of the tunnel flow-field and can be exploited to significantly reduce the subsequent computational burden. This work will benefit the entire spectrum of AEDC activities, including pre-test analysis and design, on-line test interpretation, post-test analysis and extrapolation to flight conditions. It will benefit Air Force weapons development in general and provide significant new basic information on the structure of confined transonic flows.

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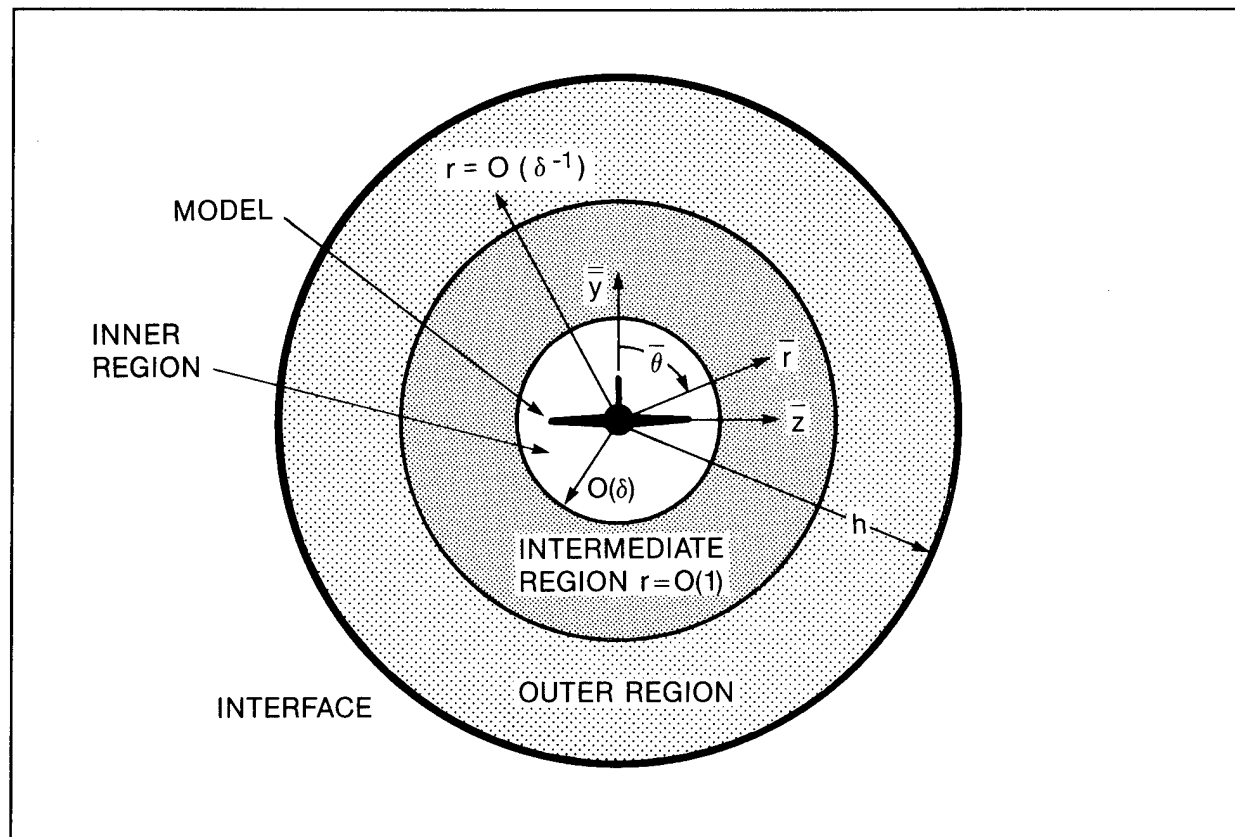


Figure 15. Front view of wind tunnel model confined by cylindrical walls, showing important regions.

Automated Sharing of Knowledge Bases May Yield Better Planning Capabilities

Although there is a great need for knowledge bases within DOD to share their information, to date the lack of adequate translation technology (interlingua) has prevented general knowledge sharing. For example, it is not possible to unambiguously translate a statement about multi-function aircraft to a knowledge base that does not "know" what multi-function is. Professor Jeffrey Van Baalen of the University of Wyoming demonstrated his new prototype interlingua translator to translate the complete Defense Advanced Research Projects Agency/Rome Laboratory Planning Initiative knowledge base from its original language (LOOM) to a less expressive one (CLASSIC). At the heart of Van Baalen's translator is a technique that uses information within the knowledge base itself to reformulate non-uniquely translatable statements into ones which are translatable.

Many Air Force systems will benefit from Van Baalen's accomplishment. For example, an air route planning knowledge base is a collection of a number of knowledge bases assembled from different sources and written in their own specialized languages. One knowledge base consists of flight schedules. Another includes different carrier capabilities, maintenance needed, and fuel consumption under different conditions. Another contains information about crew availability, regulations governing work and rest periods, and standby and replacement locations. The new translator will allow the knowledge bases to share information, provide more planning options, and ensure error-free, consistent planning capability.

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Recognition of AFOSR Researchers

The many awards received by principal investigators in 1992 provides ample evidence of the quality of people working under AFOSR sponsorship. The scientists and engineers who have worked for AFOSR since its inception have been of the highest caliber. In the slightly more than 40 years of its existence, AFOSR has supported the work of about two dozen scientists who, later, have been awarded the Nobel prize as well as a host of scientists who have won other prestigious awards. The scientists listed below are illustrative of this latest chapter in a long success story.

Two Principal Investigators Elected to the National Academy of Engineering

Professor Ted Belytschko of Northwestern University was recently elected to the National Academy of Engineering. Scientists and engineers are selected for this recognition based on national and international contributions to their field. Professor Belytschko was elected to the Academy for his work in the field of non-linear mechanics, especially the simulation of materials instability and failure processes. His work has contributed significantly to understanding and modeling of failure and life-time prediction methods of advanced aerospace structures. Professor Belytschko's research programs on non-linear mechanics and materials stability have been sponsored by the AFOSR Structural Mechanics Program for six years.

Professor Frank E. Karasz of the University of Massachusetts, an AFOSR researcher for 25 years, was also elected to the National Academy of Engineering in 1992. He is one of only a select few academic polymer scientists to become a member of the academy. Professor Karasz was appointed associate professor in the Department of Polymer Science and Engineering at the University of Massachusetts in 1967, the same year he received his first AFOSR research grant for investigations of the thermodynamics of glass formation in polymers.

Professor Karasz has greatly expanded his research interests in the 25 years he has worked with AFOSR support to include the areas of high pressure effects in solid polymers, quasi-electric light scattering in polymer solutions, high temperature polymer blends, and electro-optically active polymers. In 1986, he became the director of the new Center for Advanced Electrical and Structural Polymers funded by an AFOSR-DARPA University Research Initiative award. His research on miscible blends led to a transition research program conducted by a consortium of companies including Hoechst Celanese, Lockheed, General Electric and the University of Massachusetts. The consortium plans to test the feasibility of using new high temperature polymer blend materials for advanced aircraft applications.

Researchers Elected to National Academy of Sciences

Professor Jan D. Achenbach of Northwestern University, an AFOSR researcher for ten years, was recently elected to the National Academy of Sciences. He was already a member of the National

Academy of Engineering and thus became one of only 132 scientists elected to both prestigious national institutions. Professor Achenbach was also named the 1992 recipient of the Timoshenko Medal given by the American Society of Mechanical Engineers. The medal is awarded annually to the single researcher who has contributed most to the field of mechanics.

AFOSR has sponsored Professor Achenbach's research in the areas of composite materials, nondestructive evaluation and "smart" materials and structures. He is presently engaged as the principal investigator in an AFOSR Directorate of Aerospace Sciences sponsored project entitled "Mechanics of Smart Structures." The objective of this project is to determine mechanically optimal locations and types of sensor or actuator elements that are suitable for structurally-integrated nondestructive evaluation (NDE) systems. The basic idea is to embed an array of optical fibers in the structure to thermoelastically generate ultrasound and pickup the transmitted ultrasound by means of another array of optical fiber interferometers. By proper phasing of laser signals through each element of the array of generating fibers, the ultrasound can be scanned over a wide region of the structure. The use of an array of receiving fibers will enable the detection of anomalies arising from distributed damage or larger defects such as cracks. This technology is the key to the development of a real-time "health monitoring system" to assess the integrity of structures and provide the Air Force with a more effective maintenance system.

Dr. Thomas J. Ahrens, a professor of Geophysics at the California Institute of Technology, was also elected to the National Academy of Sciences. For nearly three years, Professor Ahrens has been conducting research into high-velocity impacts on rocks to study their failure mechanisms and the rheology of shock-loaded brittle materials. His research is funded under the AFOSR Particulate Mechanics Program. He is conducting experiments to determine the dynamic, inelastic behavior of rocks and relate the observed behavior to the existing theories of brittle failure developed from quasi-static experiments. A fundamental understanding and quantitative description of this behavior could lead to the improved design and evaluation of Air Force underground and protective structures.

Aerospace Sciences Researcher Elected Fellow of American Physical Society

Professor David Walker of Lehigh University was honored as a Fellow of the American Physical Society. Professor Walker's major research contributions have been in the areas of computational fluid dynamics, boundary-layer turbulence, unsteady viscous flows, heat and mass transfer, materials processing, and numerical methods. He was honored as a Fellow of the American Physical Society for his remarkable insight into complicated fluid dynamics problems, particularly for formulating and analyzing a high Reynolds number theory for turbulent boundary layers based on the fundamental concepts of vortex dynamics. AFOSR has supported his research for the past decade. His contributions have had considerable impact on innovative research for the Air Force including the control of heat transfer on the leading edge of turbine blades and new airfoil designs to suppress vortex formation in high-angle-of-attack supermaneuvers.

Principal Investigator Receives 1992 Boltzmann Medal

Professor Joel Lebowitz of Rutgers University has been selected to receive the Boltzmann Medal, the single highest international award in the field of statistical physics. Ceremonies were held at the Technische Universitaet Berlin on August 2, 1992. The medal is awarded only once every three years by the International Commission on Statistical Physics of the International Union of Pure and Applied Physics. Previous winners include Nobel laureate Kenneth Wilson and the founder of Rigorous Statistical Mechanics, Dr. David Ruelle. Professor Lebowitz is a member of the American Academy of Science and has been supported by the Plasma Physics Subarea of AFOSR for more than a decade.

MIT Professor Honored by two National Professional Societies

MIT physics professor Daniel Kleppner received the American Physical Society's Lilienfeld Prize for outstanding contributions to physics. The award recognizes individuals who have exceptional skills in lecturing to audiences of non-specialists. He also received the Optical Society of America's Meggers Award for outstanding contributions to spectroscopy. The award recognizes his development of the hydrogen maser, spectroscopy of Rydberg states, and analysis of the interaction of atoms with electromagnetic fields.

Professor Kleppner is the Lester Wolfe Professor of Physics and Associate Director of the Research Laboratory of Electronics at MIT. He is a Fellow of the American Physical Society, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences and is a member of the National Academy of Sciences. Professor Kleppner's research on the optical metrology of magnetically-trapped hydrogen has been supported by AFOSR for three years.

Nationally Recognized Scientist Receives Additional Laurels

Professor Mildred Dresselhaus of MIT, an AFOSR contractor for over 20 years, has recently been awarded honorary Doctor of Science degrees by Princeton University, the University of Connecticut and the University of Massachusetts at Boston. She was also elected treasurer of the National Academy of Sciences for a four-year term. Professor Dresselhaus is a member of the National Academy of Sciences, the National Academy of Engineering, and is a past president of the American Physical Society. President Bush bestowed the Presidential Medal of Science on her in November 1990. An Institute Professor of Electrical Engineering and Physics, she is only one of 12 MIT faculty accorded the honor of this title. Her research for AFOSR, which focused on the physical properties of intercalated graphite materials and the electronic properties of superconductors, has been instrumental in the development of important new technologies for the Air Force.

Postdoctoral Researcher Receives the R. W. P. King Prize

Dr. Thorkild P. Hansen, supported by AFOSR as a National Research Council Postdoctoral Research Associate at Rome Laboratory, Hanscom AFB, Mass., was awarded the R.W.P. King Prize by the Antennas and Propagation Society of the IEEE. Dr. Hansen was recognized for his paper on "Corner Diffraction Coefficients for the Quarter Plane." In this paper Dr. Hansen describes a method for determining the contribution made by a plate corner (a wing tip for example) to the scattered electromagnetic field. This should prove beneficial in future design efforts directed at low observable platforms.

The R.W.P. King Prize is awarded annually for the best paper by an author, under 36 years of age, that appeared in the previous year's IEEE Transactions on Antenna and Propagation. Dr. Hansen completed this paper while working with Dr. Arthur Yaghjian, a member of AFOSR's Electromagnetic Scattering Star Team at the Air Force's Rome Laboratory.

Neural Researcher Honored at International Conference

Professor Walter Freeman of the University of California, Berkeley received two honors during the 1992 International Joint Conference on Neural Networks held this June in Baltimore. From 1986 to 1991, AFOSR sponsored much of Professor Freeman's research in the fields that led to the awards. Professor Freeman received the IEEE Pioneer Award for his groundbreaking work demonstrating that cortical networks can be modeled as populations of mutually coupled oscillators. These award winning contributions to computational olfaction, the emulation of the brain's ability to detect and identify odors starting with the most significant and progressing through lesser ones, may eventually play a critical role in enhancing Air Force signal detection and classification systems by allowing multiple sensor inputs to be classified in prioritized order. These contributions could also be useful in Identification Friend, Foe or Neutral (IFFN) systems to discriminate among targets in a "rich" environment.

As a result of his accomplishments, Professor Freeman was also given a MERIT ("Javitz") Award by the National Institute of Mental Health. The stipend accompanying this award will allow Professor Freeman to continue his research in this vital area.