This is an excerpt from

Air Force Office of Scientific Research
Broad Agency Announcement 2005-1

Ongoing Until Superceded. Download date: July 13, 2005.

Documents of this kind are *always* subject to revision. For this reason, before preparing and submitting a proposal, *always* confirm that your source document is still current and make certain to obtain any subsequent modifications or appendices. Upon request, our office would be pleased to help you in this regard.

Tom Murphy
Office of Intellectual Property & Sponsored Research
Brookhaven National Laboratory
Extension 3312
E-mail: tmurphy@bnl.gov

III. RESEARCH INTERESTS

AFOSR plans, coordinates, and executes the Air Force Research Laboratory's (AFRL) basic research program in response to technical guidance from AFRL and requirements of the Air Force; fosters, supports, and conducts research within Air Force, university, and industry laboratories; and ensures transition of research results to support USAF needs.

The focus of AFOSR is on research areas that offer significant and comprehensive benefits to our national warfighting and peacekeeping capabilities. These areas are organized and managed in four scientific directorates: Aerospace and Materials Sciences, Physics and Electronics, Chemistry and Life Sciences, and Mathematics and Space Sciences. The research activities managed within each directorate are summarized in this section.

AFOSR seeks technical options that address our need for heightened attention to homeland defense and the Global War on Terrorism, funding those good ideas that are relevant to the Air Force role, and assisting in getting other good ideas to the agencies that may find them of special relevance to their roles.

Aerospace and Materials Sciences

The Directorate of Aerospace and Materials Sciences is responsible for research activities in aerospace, engineering, and materials. The four major projects in the directorate are solid mechanics and structures, structural materials, fluid dynamics, and propulsion. An equally important mission of the directorate is to support multidisciplinary efforts to meet Air Force science and technological needs. The structural materials activities in the directorate and the chemistry activities supported by the Directorate of Chemistry and Life Sciences form an integrated AFOSR structural materials program. The control theory and mathematical modeling research supported by the Directorate of Mathematics and Space Sciences complements many structural, fluid mechanics, and propulsion research programs supported by this directorate. Research areas of interest to the Air Force program managers are described in detail in the Subareas below.

Structural Mechanics

The objective of this research program is to create enabling technology for the development of Air Force systems by supporting fundamental studies that will expand the design space for future structures. There is also great interest in fundamental studies that will enable the Air Force to maintain the integrity and function of existing aerospace structures, as well as enhance their performance. Proposals are sought for studies that will enable the exploitation of large nonlinear structural deformations under coupled fluid, thermal, and mechanical loads. Examples include novel actuation devices and the exploitation of aeroelastic phenomena for flapping-wing micro air vehicles. The emphasis will be on gaining the understanding required to use nonlinear phenomena in novel ways, as opposed to, *e.g.*, simply characterizing flutter boundaries. Another major program thrust will be novel approaches to the design of reconfigurable structures. Both mechanical and materials (*e.g.*, shape memory alloys) based approaches are of interest. Novel structure concepts are of interest at any scale (nano, MEMS, large deployable structures) and for any purpose (sensing, controlling, stiffening, actuation, etc.) that supports air- and space-based applications. Other specific areas of interest include structural health monitoring and thermal protection systems. Other proposals, for structural innovations in areas not specifically mentioned above, are welcome.

Capt Clark Allred AFOSR/NA (703) 696-7259
DSN 426-7259 FAX (703) 696-8451
E-Mail: clark.allred@afosr.af.mil

Mechanics of Materials and Devices

The main goals of this program are to develop safer, more durable aerospace vehicles/subsystems with improved performance characteristics; and to bridge the gap between the viewpoints from aerospace materials and devices on one side and aerospace structures on the other in forming a science base for the materials development process. Specifically, the program seeks to establish the fundamental understanding required to design and manufacture multifunctional aerospace material systems and devices and to predict their performance and structural integrity. The multifunctionality implies coupling between structural performance and other as-needed functionalities such as electrical, magnetic, optical, thermal, biological, and so forth. Structural integrity includes durability, survivability, reliability, and maintainability. This program thus focuses on developing and applying multifunctional mechanics principles and design methodology based on physics, chemistry, biology, and artificial intelligence to model and characterize the processing and performance of multifunctional material systems and devices at multiple scales. Projected Air Force applications require material systems and devices capable of sustained performance in complex or hostile loading environments. Such systems and devices often consist of different materials with different functionalities. Examples include hybrid structural materials, advanced fiber composites, solid rocket propellants, functionally graded material systems, and a variety of micro-devices. Innovative new material systems and devices, such as autonomic materials, nanocomposites, and micro/nano electromechanical systems, are also of interest. Interaction with Air Force Research Laboratory researchers is encouraged to maintain relevance and enhance technology transition.

Dr. Les Lee AFOSR/NA (703) 696-8483
DSN 426-8483 FAX (703) 696-8451
E-Mail: les.lee@afosr.af.mil

Unsteady Aerodynamics and Hypersonics

The unsteady aerodynamics and hypersonics research program is focused on providing the fundamental fluid physics research base for future aerospace systems. Through a balance of experiments, analytical modeling, and numerical simulations a fundamental understanding of the basic fluid phenomena associated with complex configurations is achieved. This increased knowledge base enables methods for flow prediction and optimization that, in the short-term, will reduce the weight and cost of future systems, and in the long-term, will enable completely new, revolutionary vehicle designs.

Unsteady aerodynamics is a key element in the development and optimization of future unmanned highly maneuverable air vehicles. Research areas of interest include understanding the basic mechanisms present in time-dependent aerodynamic flows, with emphasis on characterization, prediction, and control of separated and vortical flows. Nonlinear aero-structure interaction research, including approaches for control and suppression of destructive flow-structure interactions, is also of interest. Aero-acoustics research, especially as it applies to airframe noise or sonic fatigue, would also be considered a part of the aero-structure interaction emphasis.

Hypersonic aerodynamics research is critical to the Air Force's renewed interest in long-range and space operations. The size and weight of a hypersonic vehicle, and thus its flight trajectory and required propulsion system, are largely determined by aerothermodynamic considerations. Research areas of interest emphasize the characterization, prediction and control of high-speed fluid dynamic phenomena including boundary layer transition, shock/boundary layer, and shock/shock interactions, and other phenomena associated with airframe propulsion integration. Real-gas effects, plasma aerodynamics, magnetohydrodynamics, and heat transfer in high-speed flows are also of interest.

Dr. John Schmisseur AFOSR/NA (703) 696-6962
DSN 426-6962 FAX (703) 696-8451
E-Mail: john.schmisseur@afosr.af.mil

Turbulence and Rotating Flows

Research in turbulence and rotating flows is primarily motivated by Air Force requirements for airbreathing propulsion systems and advanced flight controls. In this context, the program seeks to advance fundamental understanding of complex, turbulent flows, and to apply that understanding to the development of physically based predictive models and innovative concepts for active flow control.

Research contributing to the understanding of flow instabilities and the mechanisms of transition from laminar to turbulent flow in both bounded and free-shear flows is of interest, especially as it relates to the impact on flow controllability and turbine engine flow fields. Improved turbulence modeling approaches are sought for the prediction of flow and heat transfer in highly strained turbulent flows. In this context, original ideas for modeling turbulent transport, especially ideas for incorporating the physics of turbulence into predictive models are sought. Improved subgrid models for large eddy simulations (LES) methods, especially in the near-wall region, and high quality turbulent flow data relevant to the advancement of transport and subgrid models for high-Reynolds number turbulent flows, are also of interest.

Research that addresses fundamental flow phenomena occurring in gas turbine engines, emphasizing the roles of unsteadiness, high freestream turbulence, multiple blade row interactions and three-dimensionality in determining the performance, stability, and heat-transfer characteristics of these flows, is encouraged. Methods for prediction and control of compressor instabilities, and aerodynamic forcing contributing to high cycle fatigue phenomena are of interest. Another principal concern is the prediction and control of heat transfer in gas turbines, including both film-cooling and internal-cooling flows. Other areas of interest include separation control, shock impingement effects, stagnation-point heating, blade tip clearance flows, and transition in high roughness, high freestream turbulence conditions.

Active flow control approaches based on understanding, modeling, and controlling fundamental flow processes are a focus area in this program. These approaches include the exploration of innovative sensors and actuation concepts, reduced order modeling, and fluids-based flow and flight control strategies, addressing a broad class of flow control problems related to fluidic thrust vectoring, internal duct flow tailoring, high lift, enhanced jet mixing, aero-optics, and drag reduction.

This program is also interested in ideas exploring frontiers in fluid mechanics relating to fundamental flow processes occurring in microscale devices.

Dr. Thomas Beutner AFOSR/NA (703) 696-6961
DSN 426-6961 FAX (703) 696-8451
E-mail: tom.beutner@afosr.af.mil

Combustion and Diagnostics

Fundamental understanding of the physics and chemistry of multiphase, turbulent reacting flows is essential to improving the performance of chemical propulsion systems, including gas turbines, ramjets, scramjets, pulsed detonation engines, and chemical rockets. AFOSR is interested in innovative research proposals that use simplified configurations for experimental and theoretical investigations.

The highest priorities are studies of supersonic combustion, atomization and spray behavior, fuel combustion chemistry, supercritical fuel behavior in precombustion and combustion environments, plasma-enhanced ignition and combustion, and novel diagnostic methods for experimental measurements.

In addition to achieving fundamental understanding, AFOSR seeks innovative approaches to produce reduced models of turbulent combustion. These models would improve upon current capability by producing prediction methods that are both quantitatively accurate and computationally tractable. They would address all aspects of multiphase turbulent reacting flow, including such challenging objectives as predicting the concentrations of trace pollutant and signature producing species as products of combustion. Approaches such as novel subgrid-scale models for application to large eddy simulations of subsonic and supersonic combustion are of interest.

Dr. Julian M. Tishkoff, AFOSR/NA (703) 696-8478
DSN 426-8478 FAX (703) 696-8451
E-mail: julian.tishkoff@afosr.af.mil

Space Power and Propulsion

Research activities fall into three areas: nonchemical orbit-raising propulsion, chemical propulsion, and plume signatures/contamination resulting from both chemical and nonchemical propulsion. Research in the first area is directed primarily at advanced space propulsion, and is stimulated by the need to transfer payloads between orbits, station-keeping, and pointing, including macro- and nanosatellite propulsion. It includes studies of the sources of physical (nonchemical) energy and the mechanisms of release. Emphasis is on understanding electrically conductive flowing propellants (plasmas or charged particles) that serve to convert beamed or electrical energy into kinetic form. Theoretical and experimental investigations focus on the phenomenon of energy coupling and the transfer of plasma flows in electrode and electrodeless systems under plasma dynamic environments.

Topics of interest include characteristics of pulsed and steady-state plasmas; scaling physics; characteristics of equilibrium and non-equilibrium flowing plasma; characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface, plasma-electrode, plasma-magnetic, and plasma-electric fields; losses to inert parts; characteristics of plasmas in high-magnetic fields and pressures; and plasma diagnostics (new and unique non-interfering measuring techniques).

Research is sought on chemical propulsion to predict and suppress combustion instabilities in liquid rocket systems and pulsed detonation rocket engines. Topics of interest include the modeling of the coupling among unsteady flows, combustion, acoustic fields, and chemical kinetics, detonation phenomenon, modeling using novel tools such as molecular dynamics, direct simulation Monte Carlo, and hybrid approach.

Dr. Mitat A. Birkan AFOSR/NA (703) 696-7234
DSN 426-7234 FAX (703) 696-8451
E-Mail: mitat.birkan@afosr.af.mil

Metallic Materials

The objective of basic research in metallic materials is to provide the fundamental knowledge required to develop and improve metallic alloys for economically sustainable use in aerospace applications. Applications of these materials include aircraft gas turbine engines, engines for rocket propulsion, components of airframe and spacecraft structures, and hypersonic vehicle systems. This objective will be met by developing and verifying physics-based, quantitative, predictive models that relate processing, chemistry, and structure with properties and performance of metallic materials. Representative scientific topics include the development and experimental verification of theoretical and computational models of material processing and behavior, processing science, phase transformations, interfacial phenomena, strengthening mechanisms, plasticity, creep, fatigue, environmental effects, and fracture. Research on improved performance for low-cost operation and maintenance of metallic structural materials is also encouraged. Materials included in current projects include lightweight structural metals, refractory metals, intermetallic alloys, amorphous alloys and their composites, and micro-laminated materials.

Dr. Craig S. Hartley AFOSR/NA (703) 696-8523
DSN 426-8523 FAX (703) 696-8451
E-Mail: craig.hartley@afosr.af.mil

Ceramic and Nonmetallic Materials

The objective of this research program is to provide scientific background for current and future Air Force-related applications of ceramics, ceramic-matrix composites (CMCs), and carbon-based composites. Of particular interest are new ceramic materials that are lightweight and are high-temperature-resistant (>1500 °C) for application in structural elements for hypersonic aircraft and space structures. To facilitate their use, these materials' resistance to oxidation must be improved, and lower cost processing routes need to be developed. Incorporation of modeling and simulation into the design of new ceramic materials with superior mechanical properties (especially at elevated temperatures and under extreme chemical environments) is encouraged.

The incorporation of multifunctionality as an inherent property requirement of structural ceramic materials offers the immediate opportunity to improve performance by reducing weight and improving strength and toughness, while at the same time providing tools such as integrated detection, diagnosis, and repair modes. New approaches to designing multifunctional-structural ceramics are encouraged. Toughening techniques (i.e. phase transformation or texturing) that manipulate the ceramic microstructure are excellent opportunities to incorporate additional functionality into the material. In addition, new chemistries and processing techniques that have not been explored for multifunctional ceramics are prime candidates for designing a wide range of smart structural ceramics (i.e. geopolymers, molten salt processing, hydrogen assisted processing and/or electric and magnetic field enhanced synthesis). One proposed model for a smart structural ceramic would be a material that is aware of its environment and is 1) self-monitoring, 2) self-diagnosing, and 3) self-repairing.

Dr. Joan Fuller AFOSR/NA (703) 696-7236
DSN 426-7236 FAX (703) 696-8451
E-Mail: joan.fuller@afosr.af.mil

Organic Matrix Composites

This program addresses the materials science issues relating to the use of polymer matrix fiber reinforced composites and related material technologies in aerospace and space structures such as airframes, engine components, rocket, launch vehicles and satellites. The goal is to provide the science and knowledge base that will lead to higher performance, more durable, more affordable structures for Air Force applications. The approach is to address issues relating to the development of improved performance or lower cost polymer-matrix composite (PMC) systems and the processing and the utilization of these structures during deployment. Chemistry and processing of structural adhesives and carbon-carbon structures are also within the scope of this program. Materials issues relating to all material preforms and processing leading to the end components are of interest. Examples of these include resin chemistry and formulations, prepregs processing, dry preforms, lay-up operation and cure processes.

Innovative material concepts that will lead to higher temperature and more damage-tolerant composites, lower cost processing and fabrication, and improved materials for space operations and launch vehicles are sought.

Current research interests include high performance adhesive and pre-damage nondestructive evaluation of adhesive bonded structures. High-temperature and/or low-shrinkage adhesives are needed to improve performance of high-temperature components and adhesive-bonded joints. New nondestructive evaluation methods that will probe chemical bonding integrity instead of macroscopic damage are of interest. Nanocomposite concepts that are relevant to improving or replacing current carbon fiber reinforced composites are of interest. The research targets in this area can address the matrix resin, fiber, ply or laminate level. Carbon-carbon concepts suitable for structural application in the temperature range of 700° to 1200°F, and material approaches to alleviate residual stresses and microcracking in composites, especially at cryogenic temperature range, are also areas of interest. Research that can improve the use of computational methods in accelerating new materials development and component design of polymer matrix composites is encouraged.

Dr. Charles Y-C Lee AFOSR/NL (703) 696-7779
DSN 426-7779 FAX (703) 696-8449
E-Mail: charles.lee@afosr.af.mil