BROAD AGENCY ANNOUNCEMENT (BAA)

1. **Agency Name**

Air Force Office of Scientific Research
Arlington VA

2. **Funding Opportunity Title**

Research Interests of the Air Force Office of Scientific Research

3. **Announcement Type**

This is the initial announcement.

4. **Funding Opportunity Number**

AFOSR-BAA-2009-1

5. **Catalog of Federal Domestic Assistance (CFDA) Numbers**

12.800

6. **Due Dates**

This announcement remains open until superseded. Proposals are reviewed and evaluated as they are received. Proposals may be submitted at any time.

7. **Additional Overview**

The Air Force Office of Scientific Research (AFOSR) manages the basic research investment for the U.S. Air Force (USAF). As a part of the Air Force Research Laboratory (AFRL), AFOSR's technical experts foster and fund research within the Air Force Research Laboratory, universities, and industry laboratories to ensure the transition of research results to support USAF needs. Using a carefully balanced research portfolio, research managers seek to create revolutionary scientific breakthrough, enabling the Air Force and U.S. industry to produce world-class, militarily significant, and commercially valuable products.

To accomplish this task, AFOSR solicits proposals for basic research through this general Broad Agency Announcement (BAA). This BAA outlines the Air Force Defense Research Sciences Program. AFOSR invites proposals for research in many broad areas. These areas are described in detail in Section I, Funding Opportunity Description.

AFOSR is seeking unclassified, fundamental research white papers and proposals that do not contain proprietary information.

It is anticipated the awards will be made in the forms of grants, cooperative agreements or contracts. AFOSR reserves the right to select and fund for award; all, some, or none of the proposals in response to this announcement.

This announcement will remain open until replaced by a successor BAA. Proposals may be submitted at any time. However, those planning to submit proposals should consider that AFOSR commits the bulk of its funds in the Fall of each year.

AFOSR will not issue paper copies of this announcement. AFOSR provides no funding for direct reimbursement of proposal development costs. Technical and costs proposals, or any other material, submitted in response to this BAA will not be returned.

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I. Funding Opportunity Description

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 three scientific directorates: Aerospace, Chemical and Material Sciences, Physics and Electronics, and Mathematics, Information and Life Sciences. The research activities managed within each directorate are summarized in this section.

Aerospace, Chemical and Material Sciences (NA)

The Aerospace, Chemical and Material Science Directorate strives to find, support, and foster new scientific discoveries that will ensure future novel innovations for "The Future AF". The Directorate leads discovery and development of fundamental and integrated science that advances future air and space power. Five scientific focus areas are the central research direction for the Directorate focused to meet the following strategy. "If it has structure and rises above the ground, then the directorate has responsibility leading the discovery and development of fundamental and integrated science that advances future air and space power". This alignment is not limited to the size, speed, or operating elevation and encompasses the entire operating spectrum for "The Future AF" to ensure universal situational awareness, delivery of precision effects and access and survivability in the battlespace. The five scientific focus areas provide broad scientific challenges where development of new scientific discoveries will enable future technology innovations necessary to meet the needs of "The Future AF". The five scientific focus areas are:

1) Aero-Structure Interactions and Control
2) Energy, Power and Propulsion
3) Complex Materials and Structures
4) Space Architecture and Protection
5) Thermal Control

A wide range of fundamental research addressing structures, structural materials, fluid dynamics, propulsion, and chemistry are brought together to address these multidisciplinary topics in an effort to increase performance and operational flexibility.

1) Mechanics of Multifunctional Materials and Microsystems, Dr. Les Lee

2) Structural Mechanics, Dr. Victor Giurgiutiu and Dr. David Stargel
3) Surface and Interfacial Science, Maj. Michelle Ewy
4) Organic Materials Chemistry, Dr. Charles Lee
5) Theoretical Chemistry, Dr. Michael Berman
6) Molecular Dynamics, Dr. Michael Berman
7) High Temperature Aerospace Materials, Dr. Joan Fuller
8) Low Density Aerospace Composites, Dr. Charles Lee
9) Hypersonics and Turbulence, Dr. John Schmisseur
10) Flow Control and Aeroelasticity, Dr. John Schmisseur
11) Space Power and Propulsion, Dr. Mitat Birkan
12) Combustion and Diagnostics, Dr. Julian Tishkoff

Research areas of interest to the Air Force program managers are described in detail in the Sub areas below.

1. Mechanics of Multifunctional Materials & Microsystems

The main goals of this program are to establish safer, more maneuverable aerospace vehicles and platforms with improved performance characteristics; and to bridge the gap between the viewpoints from materials science on one side and structural engineering on the other in forming a science base for the materials development and integration criteria. Specifically, the program seeks to establish the fundamental understanding required to design and manufacture new aerospace materials and microsystems for multifunctional structures and to predict their performance and integrity based on mechanics principles. The multifunctionality implies coupling between structural performance and other as-needed functionalities (such as electrical, magnetic, optical, thermal, chemical, biological, and so forth) to deliver dramatic improvements in system-level efficiency. Structural performance includes durability, reliability, survivability, maintainability and the ability to reconfigure, in response to the changes in surrounding environments or operating conditions. Among various visionary contexts for developing multifunctionalities, the concepts of particular interest are: (a) “autonomic” structures which sense, diagnose and respond for adjustment with minimum external intervention, and (b) “adaptive” structures allowing reconfiguration or readjustment of functionality, shape and mechanical properties on demand. This program thus focuses on the developing new design criteria involving mechanics, physics, chemistry, biology, and information science to model and characterize the integration and performance of multifunctional materials and microsystems at multiple scales from atoms to continuum. Projected Air Force applications require material systems and devices which often consist of dissimilar constituents with different functionalities. Interaction with Air Force Research Laboratory researchers is encouraged to maintain relevance and enhance technology transition.

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2. Structural Mechanics

This fundamental basic research program addresses the US Air Force needs in the following application areas: 1) New and revolutionary flight structures, 2) Sustainment of Air Force fleet for mission readiness under all conditions, and 3) Structural dynamics under non-stationary conditions and extreme environments. Other game-changing and revolutionary structural mechanics problems relevant to the US Air Force are also of interest.

The structural mechanics program encourages fundamental basic research that will generate understanding, models, analytical tools, numerical codes, and predictive methodologies validated by carefully conducted experiments.

Fundamental basic research issues for new and revolutionary flight structures include: revolutionary structural concepts and unprecedented flight configurations; reconfigurable adaptive structures with on-demand shape morphing for real-time respond to changing missions demands and threat environment; hybrid structures of dissimilar materials (metallic, composite, ceramic, etc.) with multi-material joints and/or interfaces under dynamic loads, blast, and extreme environments; controlled-flexibility distributed-actuation smart structures; physics-based models that quantitatively predict the materials performance and durability of metallic and composite flight structures operating at various regimes. The predictive analysis and durability prognosis of hybrid-material structures that synergistically combine the best attributes of metals, composites, and ceramics, while avoiding their inherit shortcomings is of great interest. The dissimilar-material joints with wide coefficient of thermal expansion mismatch while exposed to temperature cycling, environmental degradation, and dynamic/blast loading should be considered. There is a special interest in exploring the current state of art and expanding the understanding and use of both Spectral Finite Element Analysis and Peridynamics.

Fundamental basic research issues for sustainment include: prediction of the structural flaws distribution and service-induced damage on each aircraft and at fleet level; structural analysis that accounts for variability due to materials, processing, fabrication, maintenance actions, changing mission profiles; on-board health monitoring and embedded NDE ; and prediction of structural “hot spots”.

Fundamental basic research issues for structural dynamics include: control of dynamic response of extremely flexible nonlinear structures; control of unsteady energy flow in nonlinear structures during various flight conditions; unsteady nonlinear structural dynamics in interaction with air flow, unsteady heating, directed energy, and servo-controls at various Mach and Reynolds numbers; nonlinear dynamics and vibration control of thin-wall structures of functionally graded hybrid materials with internal vascular networks under extreme loading conditions.

Researchers are highly encouraged to submit short white papers prior to developing full proposals. White papers are encouraged as an initial and valuable step prior to proposal development and submission. White papers should briefly relate the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort. Researchers with white papers of significant interest will be invited to submit full proposals.

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3. Surface and Interfacial Science

Understanding the chemistry, physics and mechanics of surfaces and their interfaces is critical to a wide range of Air Force technologies, particularly as we look towards miniaturization of assets. This program is interested in discovering fundamental mechanisms of behavior that could later be used to guide material design with specific surface and interfacial properties. The focus is on chemical and physical mechanisms that apply to a wide range of materials rather than Edisonian investigations of individual materials, unless these are used solely as a proof of principle.

The research currently funded under this program falls into two broad categories: tribology and surface interactions. The tribology program investigates basic chemical phenomena at the interface through experiments and molecular dynamics, fundamental mechanisms of friction and wear, multi-scale investigations of tribological properties, and the development of tools for the in situ monitoring of tribological and mechanical properties. The surface interactions program probes basic chemical phenomena resulting from non-tribological perturbation of surfaces. Specific consideration is given to research focused on uncovering key, broad applicable mechanisms of quantum, atomic and molecular behavior at and on surfaces.

In particular, the program hopes to understand how surface chemistry may be used to create materials and structures with unprecedented and/or tunable thermal and spectral properties. For both programs, solid/solid and solid/fluid interfaces with relevance to Air Force applications are of interest.

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4. Organic Materials Chemistry

The goal of this research area is to gain a better understanding of the influence of chemical structures and processing conditions on the properties and behaviors of polymeric and organic materials. This understanding will lead to development of advanced organic and polymeric materials for Air Force applications. This program's approach is to study the chemistry and physics of these materials through synthesis, processing, and characterization. This area addresses both functional properties and properties pertinent to structural applications. Materials with these properties will provide capabilities for future Air Force systems to achieving global awareness, global mobility, and space operations.
Proposals with innovative material concepts that will extend our understanding of the structure-property relationship of these materials and achieve significant property improvement over current state-of-the-art materials are sought. Current interests include photonic polymers and liquid crystals, polymers with interesting electronic properties, polymers with controlled dielectric permittivity and magnetic permeability including negative index materials, and novel properties polymers modified with nanostructures. Applications of polymers in extreme environments, including Space operation environments, are of interests. Novel materials concepts that will enable multifunctional, reconfigurable, or adaptive structures are encouraged.

In the area of photonic polymers, research emphases are on materials whose refractive index can be actively controlled. These include, but are not limited to, electrooptic polymers, liquid crystals, photorefractive polymers and magneto-optical polymers. Organic molecules with large nonlinear absorption are also of interest. Examples of electronic properties of interest include conductivity, charge mobility, electro-pumped lasing and solar energy harvesting. Material concepts related to power generation and storage are also of interest. In the area of structural properties, polymers with high thermomechanical properties are desirable. End uses of these structural polymers include aircraft and rocket non-fiber reinforced composite components such as canopies, coatings, and special properties polymers. Issues relating to extreme environments, thermal, thermoxidative, radiation, atomic oxygen bombardment and extreme mechanical loading are of interests. Nanotechnology approaches are encouraged to address all the above-mentioned issues. Approaches based on biological systems to achieve materials properties that are difficult to achieve through conventional means are of interest.

Organic based materials, including inorganic hybrids, with controlled magnetic permeability and dielectric permittivity are also of interest. Of great interest are multifunctional materials with non-trivial, low-loss permittivity and permeability at frequencies greater than 100 MHz, especially those functioning at greater than 1 GHz. This interest extends into 3-D bulk materials with negative index (both permittivity and permeability being negative).

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5. Theoretical Chemistry

The major objective of the theoretical chemistry program is to develop new methods that can be utilized as predictive tools for designing new materials and improving processes important to the Air Force. These new methods can be applied to areas of interest to the Air Force including the structure and stability of molecular systems that can be used as advanced propellants; molecular reaction dynamics; and the structure and properties nanostructures and interfaces. Interest in advanced propellants is concentrated in the High Energy Density Matter (HEDM) Program, which aims to develop new propellant systems that can double the current payload capacity that can be put into orbit. Theoretical chemistry is used to predict promising energetic systems, to assess their stability, and to guide the efficient synthesis of selected candidates. These tools will help identify the most promising synthetic reaction pathways and predict the effects of condensed media effects on synthesis. This program is also seeking to identify novel energetic molecules and investigating the interactions that control or limit the stability of these systems. Particular interests in reaction dynamics include developing methods to seamlessly link electronic structure calculations with reaction dynamics, and using theory to describe and predict the details of ion-molecule reactions and electron-ion dissociative recombination processes relevant to ionospheric and space effects on Air Force systems. Interest in nanostructures and materials includes work on catalysis, surface-enhanced processes mediated by plasmon resonances. This program also encourages the development of new methods to stimulate and predict properties with chemical accuracy for systems having a very large number of atoms that span multiple time and length scales.

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6. Molecular Dynamics

The objectives of the molecular dynamics program are to understand, predict, and control the reactivity and flow of energy in molecules. This knowledge will be used to improve our understanding of interactions in the upper atmosphere and the space environment; to develop novel energetic materials for propellants and propulsion systems; to develop new high-energy laser systems; and to control chemical reactivity and energy flow at a detailed molecular level in many other chemical systems in which this will be of importance. Areas of interest in atmospheric and space chemistry include the dynamics of ion-molecule reactions relevant to processes in weakly ionized plasmas, the role of excited states in chemical reactions, and reactive and energy transfer processes that produce and affect radiant emissions in the upper atmosphere and space. Research on high energy density matter for propulsion applications investigates novel concepts for storing chemical energy in low-molecular-weight and high-density systems, and the stability and sensitivity of those energetic molecular systems. The coupling of chemistry and fluid dynamics in high speed reactive flows, and in particular, dynamics at interfaces, are also of interest. Research in energy transfer and energy storage in metastable states of molecules supports our interest in new concepts for hybrid lasers that exploit the advantages of chemical and electrical lasers. Interest in understanding and controlling processes is focused on applications to propulsion and energetics.

Materials-related research includes the study of the synthesis, structure, and properties of metal-containing molecular clusters and nanostructures. Interest in nanostructures has particular emphasis on nanoscale systems in which the number of atoms or specific arrangement of atoms in a cluster has dramatic effects on its reactivity or properties. Areas of interest include work on the mechanisms of catalysis, surface-enhanced processes mediated by plasmon resonances, and sensitive new diagnostic methods for detecting individual molecules and probing nanostructures. Utilizing catalysts to produce storable fuels from sustainable inputs and to improve propulsion processes are topics of interest. Fundamental studies aimed at developing basic understanding and predictive capabilities for chemical reactivity, bonding, and energy transfer processes are also encouraged.

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7. High Temperature Aerospace Materials

The objective of basic research in High Temperature Aerospace Materials is to provide the fundamental knowledge required to enable revolutionary advances in future Air Force technologies through the discovery and characterization of high temperature materials (nominally temperatures above 1000ºC) including: ceramics, metals, hybrid systems including composites. Applications of these materials include air-breathing and rocket propulsion systems, airframe and spacecraft structures and hypersonic vehicle systems. Specifically, the program seeks proposals that advance the field of high temperature materials research through the discovery and characterization of new materials that exhibit superior structural and/or functional performance at temperatures above 1000ºC. Representative scientific topics include the development and experimental verification of theoretical and computational models of materials discovery, characterization methods for probing microstructural evolution at elevated temperatures and mechanics of materials at elevated temperatures. There is special interest in fundamental research of high temperature materials focused on understanding combined mechanical behaviors; e.g. strength and toughness as a function of thermal and acoustic loads. This focus area will require the development of new experimental and computational tools to address the complexity of thermal, acoustic, chemistry, shear or pressure loads as they relate back to the performance of the material.

Researchers are highly encouraged to submit short (max 2 pages) white papers by email prior to developing full proposals. White papers should briefly describe the proposed effort and describe how it will advance the current state-of-the-art; an approximate yearly cost for a three to five year effort should also be included. Researchers with white papers of significant interest will be invited to submit full proposals.

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8. Low Density Aerospace Composites

This program addresses materials science issues relating to the use of polymer matrix carbon 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. Examples of these include resin chemistry and formulations, prepregs processing, dry preforms, lay-up operation, various injection molding techniques and cure processes. Mechanical behaviors and composite mechanics issues will also be included.

Innovative material concepts that will lead to higher temperature and more damage-tolerant composites, lower cost processing and fabrication, and improved materials for Air Force applications such as structures for hypersonic flights, space operations and launch vehicles and structures with enhanced thermal management capability are sought. Hybrid materials that include the use of polymer matrix carbon fiber reinforced composites for generating improved performance structures are encouraged. In this area, joining science in the formation of a durable and mechanically robust structure from different materials are encouraged. Non destructive evaluation of such joints, especially those that can detect the degradation of mechanical strength before initiation of cracks are of interests. Materials concepts that will enable reconfigurable, adaptive and multifunctional structures are encouraged.

Current research interests include high performance resin systems that can show substantial improvement over current chemistry utilized in aerospace systems. Nanocomposite concepts that are relevant to improving or replacing current carbon fiber reinforced composites or incorporating multifunctionalities in the laminate structures are of interest. The research targets in this area can address the matrix resin, fiber, ply or laminate level.

Research that can improve the use of computational methods in accelerating new materials development and component design of polymer matrix composites is encouraged. Mechanical models that can predict matrix sensitive laminate properties are encouraged. Models that enable reliable prediction of mechanical, thermal, or thermoxidative behavior of composites with 3D complex hybrid reinforcement architecture and the design of these structures to meet requirements of extreme environments are also of interests. Of particular interest are research ideas that will directly link molecular scale modeling to micromechanical models in the context of multiscale modeling that span the molecular consideration to the performance of the component structure.

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9. Hypersonics and Turbulence

The hypersonics and turbulence portfolio is focused on providing the fundamental fluid physics knowledge base for future aerospace systems. Through a balance of experiments, analytical modeling, and numerical simulations a fundamental understanding of critical fluid dynamic phenomena is achieved. Research supported by this program enables methods for flow prediction and optimization that, in the short-term, will reduce the weight, cost and fuel-consumption of future systems, and in the long-term, will enable completely new, revolutionary vehicle designs.

The behavior of the boundary layer impacts the aerodynamic performance of systems across all speed regimes of interest to the Air Force. The development of accurate methods for predicting the behavior of transitional and turbulent boundary layers across a wide range of flow conditions will facilitate the design of future systems with optimized performance and fuel-economy. To help accomplish this goal, research is solicited that will provide critical insight into the fundamental physical processes of laminar-turbulent transition and turbulent flows. 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.

Hypersonic aerodynamics research is critical to the Air Force’s 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. High-temperature gas kinetics, aerothermodynamics and interactions between the hypersonic flow and thermal protection system materials are of particular interest.

Researchers are highly encouraged to submit short (max 6 pages) white papers prior to developing full proposals. White papers are a valuable initial exercise prior to proposal development and submission. White papers should briefly describe the proposed effort and illustrate how it will advance the current state-of-the-art; an approximate yearly cost for a three year effort should also be included. Researchers with white papers of significant interest will be invited to submit full proposals.

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10. Flow Control and Aeroelasticity

The Flow Control and Aeroelasticity portfolio addresses basic research issues associated with flow control, fluid-structure interactions, vortex and shear layer flows, and low-Reynolds number and micro-air vehicle flows.

Research in this portfolio seeks to advance fundamental understanding of complex time-dependent flows, including their interactions and control, by creatively integrating theoretical, numerical, and experimental analysis techniques to develop physically-based predictive models and innovative concepts. This research encompasses both internal and external flows and their interactions for a wide range of Reynolds numbers, length scales, and speeds.

Research areas of interest include the characterization, prediction, and control of flow instabilities, heat transfer, and fluid-structure interactions for both bounded and free-shear flows with application to aero-optics, flapping wings, flexible and compliant aerodynamic surfaces, low Reynolds number flows, vortical flows and flows with significant geometric constraints; innovative flow effectors for both passive and active flow control with application to fluidic thrust vectoring, internal duct flow tailoring, enhanced jet mixing, gust alleviation, high lift, and drag reduction; and novel approaches for extracting flow energy.

Proposals are also sought for the study of the dynamic interaction between unsteady aerodynamics, nonlinear structural deformations, and aerodynamic control effectors over a wide range of flight regimes from micro-air vehicles through to hypersonic systems. The synergistic benefits of the interaction between structures, controls, and unsteady aerodynamics resulting in optimized in-flight behavior, minimized power consumption, and extended flight envelope are also of interest. Other relevant subjects will also be considered.

Researchers are highly encouraged to submit short (max 6 pages) white papers prior to developing full proposals. White papers are a valuable initial exercise prior to proposal development and submission. White papers should briefly describe the proposed effort and illustrate how it will advance the current state-of-the-art; an approximate yearly cost for a three year effort should also be included. The integration of theoretical, numerical, and experimental analysis tools to improve understanding is encouraged. Researchers with white papers of significant interest will be invited to submit full proposals.

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11. Space Power and Propulsion

Research activities fall into three areas: non-chemical launch and in-space propulsion, chemical propulsion, and plume signatures/contamination resulting from both chemical and non-chemical 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 nano-satellite propulsion. It includes studies of the sources of physical (non-chemical) 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 dynamic environments. Studies to enable revolutionary designs of satellite systems that can achieve the simultaneous objectives of increasing payload and/or time in orbit and increasing mission flexibility and scope are of interest.

Research sought on methods to predict and suppress combustion instabilities under supercritical conditions, and develop research models that can be incorporated into the design codes. Research activities include fundamental component and system level research that leads to the introduction of novel multi-use technologies and concepts, and their efficient integration at various length scales, in order to achieve multifunctional satellite architectures.

Areas of research interest may include, but are not limited to: (1) design and testing of compact, highly efficient and robust chemical or electric propulsion systems with minimal power conditioning requirements; (2) demonstration of innovative uses of power and/or propulsion systems for sensing, communication, or other applications; (3) development of highly efficient power generation/recovery systems (e.g. MEMS turbines, nano-structured thermoelectric units) deeply integrated with thermal management or spacecraft structure; (4) innovative processes that transform structural material into high energy density propellant (e.g. phase change, or even biological process); (5) novel energetic materials; and (6) development of modeling and simulation capabilities at all relevant scales.

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12. 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 liquid propellant chemical rockets. We are interested in innovative research proposals that use simplified configurations for experimental and theoretical investigations.

Our highest priorities are studies of turbulent combustion, supersonic combustion, atomization and spray behavior, liquid and gaseous fuel combustion chemistry in air, supercritical fuel behavior in precombustion and combustion environments, and novel diagnostic methods for experimental measurements.

In addition to achieving fundamental understanding, we also seek 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.

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Physics and Electronics (NE)

Research in physics and electronics generates the fundamental knowledge needed to advance Air Force operational capabilities in directed energy weapons; surveillance; electronic countermeasures; guidance and control; information and signal processing; and communications, command, and control. The program is of substantial breadth, extending from plasma and quantum physics, to the understanding of the performance of novel electronic devices, to maintaining device integrity in the harsh environment of space. The program includes theoretical and experimental physics from all disciplines, as well as engineering issues such as those found in microwave or photonic systems or materials-processing techniques. One main objective of the program is to balance innovative science and Air Force relevance, the first element being forward looking and the second being dependent on the current state of the art. This directorate takes particular pride in the strong synergistic ties it has forged between university researchers and those in the Air Force Research Laboratory community. Research areas of interest to the Air Force program managers are described in detail in the sub areas below.

1. Electro-Energetic Physics

This Air Force program seeks innovative approaches and novel concepts that can impact high power electromagnetic phenomenology for future applications relating to directed-energy weapons (DEW), radar, electronic warfare (EW), and communications. Primary interests currently encompass ideas for advancing the state-of-the-art in the following areas: electron-beam-driven sources of microwave and millimeter-wave radiation (high power microwaves [HPM] and/or vacuum electronics), compact pulsed power, particle-beam physics, next-generation combat simulation, power-efficient methods to generate and maintain significant free-electron densities in ambient air, as well as particle-beam-related micro- and/or nano-device concepts. New concepts for the detailed modeling and simulation of the above physical phenomena are also of interest.

Regarding new ideas for micro-scale or nano-scale plasma and/or vacuum electronics device concepts, MEMS concepts that could be applied to a sensor/actuator system for a future “smart” microwave tube would be exceptionally interesting.

Ideas relating to solid-state electronics, space plasmas and/or fusion plasmas are not currently of interest to this program.

Some additional funds may be added to the budgets of new grants if proposal requests the hire of US-citizen undergraduates as part-time and/or summer laboratory assistants.

Recommended first step: email a 1- or 2-paragraph abstract describing the research project being contemplated. If abstract is found to be of interest, a 2- to 5-page white paper will be encouraged.

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2. Atomic and Molecular Physics

This program encompasses fundamental experimental and theoretical AMO (Atomic, Molecular and Optical) physics research that is primarily focused on studies of cold and ultracold quantum gases, precision measurement, ultra-fast and ultra-intense laser science, and quantum information science (QIS) with atoms, molecules, and light. These research areas support technological

advances in application areas of interest to the Air Force, including precision navigation, timekeeping, remote sensing, secure communication, and metrology.
AMO physics today offers an unprecedented level of coherent control and manipulation of atoms and molecules and their interactions, allowing for significant scientific advances in the areas of cold and ultracold matter and precision measurement. Specific research topics of interest in this program include, but are not limited to, the following: physics of quantum degenerate atomic and molecular gases; strongly-interacting quantum gases; new phases of matter; cold/ultracold plasmas; ultracold chemistry; precision spectroscopy; novel clocks; and high-precision techniques for navigation, guidance, and remote sensing.

Quantum information science is a field that encompasses many disciplines of physics. AMO physics plays an important role in the development of QIS. This program is primarily focused on the following research areas in QIS: quantum simulation of strongly-correlated condensed-matter systems with cold atoms and molecules; enabling science for secure long-distance quantum communication; utilization of non-classical states of matter and light for high-precision metrology and sensing; realization of quantum states and observation of quantum behavior of macroscopic objects; application of controlled coherent interactions to direct the dynamics of quantum systems; and novel approaches to quantum information processing.

Laser pulses have reached intensities sufficient to drive electrons to relativistic speeds, and durations that are approaching time scales corresponding to atomic-scale electron dynamics. This presents enormous possibilities in the future for, e.g., next-generation microscopy and spectroscopy techniques to probe materials with unprecedented spatial and temporal resolution. Attosecond pulses will enable, for example, observation of basic processes of chemistry and biology on the scale of a single molecule. Compact sources of X-rays and directed particle beams, enabled by ultra-fast ultra-intense laser pulses, will revolutionize the study of matter, with important implications for, e.g., medical and materials diagnostics. In this program we are interested in: (1) the development of novel attosecond-pulse sources, as well as compact short-wavelength (VUV to X-rays), and directed particle beam sources; and (2) utilization of these sources to investigate processes and phenomena otherwise inaccessible in AMO physics, chemistry, biology, and materials science.

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3. Physical Mathematics and Applied Analysis

This program conducts research in physical mathematics and applied analysis to develop accurate models of physical phenomena to enhance the fidelity of simulation. It investigates the properties of coherently propagating ultrashort laser pulses through the air and their exploitation in areas such as electronic warfare (ancillary production of HPM) and laser-guided munitions (possible propagation through obscurants). It develops algorithms to simulate nonlinear optical effects within solid state lasers (with weaponization and communication in mind) and nonlinear optical media. The program supports studies in the feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators as well as the prediction of the combustion of solid rocket propellant. The program pursues descriptions of the dynamics of internal stores released from transonic or supersonic platforms as well as the enhancement of platform agility through the exploitation of plasmas. Also, it pursues the dynamics of the atmosphere near and above the tropopause with an emphasis on the understanding of atmospheric gravity wave propagation as well as turbulence and their production by topography and storms is of interest. Other areas of interest include the understanding of chaos in circuitry such as missile guidance systems, prediction of effective properties of various composite media together with models of procedures for obtaining various desired media, advanced fracture mechanics theories (which also include thermal loading such as might be produced by exposure to a strong laser).

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4. Electromagnetics

Conduct research in electromagnetics to produce conceptual descriptions of electromagnetic properties of novel materials/composites (such as photonic band gap media or negative index media) and simulate their uses in various operational settings. Evaluate methods to recognize (the inverse scattering problem) and track targets (including Improvised Explosive Devices) and to penetrate tree covers, clouds, buildings, the ionosphere, or other dispersive/random/turbulent media with wide band radar (propagation of precursors for example) and design transmitters to produce such pulses. Develop computational electromagnetic simulation codes that are rapid and accompanied by rigorous error estimates/controls.

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5. Laser and Optical Physics

Laser and optical physics research explores new ideas, knowledge, and insights in selected aspects and applications of these areas. Novel lasers and laser arrays, as well as nonlinear optical devices and phenomena are of interest. Application studies of microstructured optical fibers are ongoing and would be considered for expansion if funds are available. High brightness, narrow spectrum incoherent sources and arrays are also of interest directly for applications as well as for laser pumping. Ultrafast lasers and their applications are of interest, particularly small, lightweight, inexpensive, and high repetition rate sources, and their applications. Semiconductor laser arrays are being investigated, together with associated optics, in the mid-infrared, in support of ongoing important Air Force development programs. Directed energy beams, particularly laser beams, are being explored in novel direct-write materials-processing techniques that offer broad and extremely important new capabilities, particularly in micro-devices and micro-systems fabrication and packaging, particularly for space. Novel sources of monochromatic x-rays will be considered, particularly relatively small ones.

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6. Remote Sensing and Imaging Physics

This program investigates fundamental issues concerning remote sensing and the physics of imaging, including image formation processes, propagation of electromagnetic radiation through the environment and interacting with matter, target detection and identification, and the interaction of Air Force imaging systems and sensors with the space environment. Technological advances and miniaturization of spacecraft are driving the requirement for innovative methods to detect and identify space objects. Proposals are sought in all areas of ground, air, and space-based remote sensing and imaging, but more particularly in the detection and identification of space objects. Research goals include, but are not limited to:

1. Innovative methods of remote target location and identification, including non-imaging methods of target identification.
2. Ground based identification of space objects that are too small or too distant to image, including changes in conditions that affect target identification, such as environmental changes and surface aging or weathering.
3. Remote sensing signatures and backgrounds, particularly sensing from space and observations of space objects from the ground, and the sensing of difficult targets such as targets under foliage, buried targets, etc.
4. Enhancement of remote sensing capabilities, including novel solutions to system limitations such as limited aperture size, imperfections in the optics, and irregularities in the optical path.
5. Theoretical foundations of remote sensing and imaging.
6. Rigorous theory and models to describe the spectral and polarimetric signature from targets of interest using basic material physical properties with the goal of providing better understanding of the physics of the reflection or emission and the instrumentation requirements for next generation space surveillance systems.
7. Propagation of coherent and incoherent electromagnetic energy through a turbulent atmosphere.

8. The interaction of Air Force imaging systems and sensors with the space environment.

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7. Space Sciences

The AFOSR Space Sciences program seeks basic knowledge of the space environment to apply to the design and calibration of Air Force systems operating in and through space. For AFOSR purposes, the space environment begins at the base of the Earth's ionosphere, at an altitude of approximately 80 km (50 miles). Both the nominal and disturbed space environment can disrupt the detection and tracking of aircraft, missiles, satellites, and other targets, distort communications and navigation, and interfere with global command, control, and surveillance operations. The physical and chemical behavior of the Earth's upper atmosphere affects the performance and longevity of Air Force systems operating in low-Earth orbit. In the space environment well above low-Earth orbit, at geosynchronous orbit and beyond, phenomena such as solar eruptive events, variable interplanetary magnetic fields, solar electromagnetic radiation, natural space debris, cosmic rays, geomagnetic storm enhancement of Earth's radiation belts, and interplanetary dust can degrade Air Force spacecraft and systems. This program’s goals are to improve the global specification and forecasting of the evolution of ionospheric irregularities and scintillation, to improve the specification of thermospheric dynamics and neutral densities, and to validate and enhance current ionospheric models using data assimilation techniques to improve operational forecasting and specification capability. Research interests include, but are not limited to:

- Ionospheric plasma turbulence and dynamics;
- Observing and modeling neutral winds, atmospheric tides, and gravity waves in the ionosphere;
- Variations in solar radiation received at Earth and their effects on satellite drag;
- Geomagnetic disturbances and their impacts on the ionosphere;
- Electron density structure and ionospheric scintillation;
- Auroral and airglow evolution, as well as their spectroscopic emission signatures.
- The structure and dynamics of the solar interior and their roles in driving solar eruptive activity;
- The mechanism(s) heating the solar corona and accelerating it outward as the solar wind;
- The triggers of coronal mass ejections (CMEs), solar energetic particles (SEPs), and solar flares;
- The coupling between the solar wind, the magnetosphere, and the ionosphere;
- The origin and energization of magnetospheric plasma; and
- The triggering and temporal evolution of geomagnetic storms.

The ultimate AFOSR goal is to develop a predictive, global, coupled solar-terrestrial model that connects solar activity and output with the deposition of energy in the Earth's upper atmosphere, by specifying the flow of mass, momentum, and energy through interplanetary space, and by forecasting the turbulent plasma phenomena that mediate this flow. Innovative astronomical detection and observation methods that involve advanced technology are also of interest, as are astrophysical or astronomical research and observations that investigate stellar-planetary interactions in general and physical processes occurring in the Sun in particular.

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8. Quantum Electronic Solids

This program focuses on materials that exhibit cooperative quantum electronic behavior. The primary emphasis is on superconductors, negative-index metamaterials, and on nanoscopic electronic devices with low power dissipation and the ability to provide denser non-volatile memory, logic and/or sensing elements that have the potential to impact future Air Force electronic systems.

While the superconductivity portion of this program has long been rooted in improving the current-carrying ability and microwave properties of the cuprate (so-called high-temperature or HTS) superconductors, and more specifically YBCO, the focus starting in FY09 will on a search for new classes of superconducting materials that either have higher transition temperatures or have isotropic superconducting properties at temperatures in the range of the transition temperatures of the cuprates. It is anticipated that this major change in emphasis will be part of a coordinated international activity that is multidisciplinary in nature, and proposals that address both the physics and chemistry of potential new types of superconductors are welcome, as are multinational research efforts. While there is a long history of theorists being unsuccessful in predicting the discovery of new superconductors, there are now tools available, namely supercomputers, that have enhanced the ability to study model systems. While the emphasis of this program is on experimental research, theorists that collaborate with experimental groups are welcome to participate.

The metamaterials portion of this program is devoted to the production of 3-D metamaterials that operate over a wide swath of the electromagnetic spectrum, from microwaves, to IR and the visible. The goal is to produce materials that improve the efficiency and selectivity of and reduce the size of communications system components such as antennas, filters and lenses. Another interesting aspect is to study the ability to create sub-wavelength near-field (and possibly far-field) imaging. Additionally, these desired properties could lead to denser information storage and retrieval.

A growing aspect of this program is the inclusion of nanoscopic techniques to fabricate, characterize, and manipulate atomic-, molecular-, and nanometer-scale structures (including carbon and other elemental nanotubes), with the aim of producing a new generation of improved communications components, sensors and non-volatile, ultra-dense memory, resulting in the ultimate miniaturization of analog and digital circuitry. This program element includes the use of polarized electrons to produce nuclear magnetic polarization as a basis for dense, non-volatile memory, with possible application to quantum computing at room temperature.

Finally, there is a continuing (albeit small, monetary) interest in the development of new (soft and hard) magnetic material with high energy product at elevated temperatures to aid in providing power devices, switches and bearings for a new generation of more-electric aircraft that dispense with hydraulics and which rely, heavily on magnetic actuation.

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9. Adaptive Multi-Mode Sensing and Ultra-High Speed Electronics

This basic research program seeks to investigate and exploit novel detector and electronic material structures, device concepts, and implementation schemes vital to future U.S. Air Force system capability needs for near real-time high-fidelity remote sensing, ultra-high speed data processing & exploitation, and ultra-high bandwidth communications. Emphasis is on high-risk, high-payoff research essential to future warfighter system capability breakthroughs in performance, functionality, and robustness. The current program is organized into two thrusts:

Adaptive Multi-Mode Sensing Concepts: Emerging Air Force universal situational awareness requirements include near real-time detection, tracking and ID of low-contrast targets in broad areas of highly-cluttered dynamic scenes, and near real-time communication of resultant ‘actionable’ data to battlefield commanders. Near real-time ‘sensor-to-shooter’ capability requires remote platform target-spectra sensing and closed-loop sensor data processing, fusion, exploitation, and communications. A promising approach is ‘performance-driven’ sensing, which relies on sensing, processing, and exploiting only ‘decision-relevant’ target data in order to reduce by orders-of-magnitude requirements for data processing throughput and communications bandwidth, both essential for near real-time ‘sensor-to-shooter’ capability. ‘Decision-relevance’ is based on adaptively sensing and processing optimum sets of target-spectra data spanning UV-RF, where spectra ‘modes’ of interest include time-resolved spatial, spectral, polarization, phase, and intensity. Fusion and exploitation of optimum multi-mode spectra data is known to improve fidelity and quicken target discrimination and identification, further reducing processing and communications requirements. Dynamic selection of optimum sensor ‘modes’ and mode settings will be controlled by closed-loop ‘performance-driven’ processing and exploitation algorithms currently in development. However, vital adaptive (tunable or reconfigurable), coregistered multi-mode (vertically integrated monolithic or hybrid), staring (large area, mega-pixel) sensors don't yet exist.

Thus, the focus of this 6.1 thrust is on specific scientific challenges facing the development of future generation adaptive, high-fidelity, multi-modal detector devices enabling for future 'performance-driven' remote sensing applications. Detector and sensing concepts of interest include, but are not limited to, novel methods and concepts for achieving co-boresighted UV-RF spectra sensing, considering spatial, spectral, polarimetric, radiometric, phase, and temporal imaging (large-area) and non-imaging detection and discrimination techniques; adaptive, tunable, or reconfigurable 'pixel' and/or detector element approaches spanning multiple-modes and in one or more UV-RF bands; novel concepts for same-pixel multicolor architectures (>4 bands) with suitable pixel-to-ROIC interconnect schemes; and biologically inspired detection processes or concepts. Possible detector structures include, but are not limited to, integrated monolithic and/or hybrid approaches utilizing homogeneous and/or heterogeneous material structures; 0D, 1D, and 2D quantum and nano-based structures, and any combination there of, with a requirement that device concepts should have a reasonable expectation of yielding spectra absorption external quantum efficiencies in excess of 70%. Also, novel concepts and approaches are sought for achieving 1) monolithic linearly-graded semiconductor bandgaps in the range 0.2-4.0 eV, 2) dynamic bandgap tuning, 3) dynamic absorption coefficient tuning, and 4) dynamic spectra wavelength filter tuning.

Ultra-High Speed (THz) Digital Electronics: The focus of this thrust is ultra-high speed electronic switching devices and associated integrated circuit schemes vital to future Air Force capability needs for breakthrough-speed data processing, data exploitation, and modulation/drivers for laser communications. Emphasis is on innovative device architectures capable of THz-speed logic switching and deep-submicron scaling, based on either convergence of III-V semiconductors with traditional Si-platforms or on stand alone III-V-based platforms. Novel device and circuit concepts must be devised considering the principal virtues of III-V semiconductors, relative to Si, which include higher electron mobilities and saturation velocities, higher breakdown field strength, and the availability of semi-insulating substrates, while circumventing III-V material challenges of having: no native oxides suitable for insulated-gate transistors; poor hole mobilities/saturation velocities; difficult trap behavior at surfaces and interfaces; low Schottky barrier heights; and potential hysteresis issues. Prospective III-V-based device and circuit concepts must show potential for limiting static and dynamic power losses to comparable levels of deeply-scaled Si technologies, on the order of 100 W/cm2. While the physical scaling limits for Si-based digital electronics are expected to occur at ~ 10nm in the 2020 timeframe, due to thermal and leakage current effects, and when top clock-speeds are projected to reach 80-100GHz, there remains tremendous potential for extending the clock/switching speeds by at least a factor of 10x to 1000 GHz (THz) utilizing the unique and unparalleled properties of III-V semiconductors. In addition to logic switching applications, utilizing the III-V platform opens up breakthrough opportunities for monolithic integration of digital, mixed-signal, and electro-optic (detectors, lasers, and LEDs) applications on the same chip, offering tremendous reductions is electronics board/system size, mass, power consumption, and cost.

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10. Semiconductor and Electromagnetic Materials

This research area is directed toward developing advanced optoelectronic, magnetic and electronic materials and structures to provide improvements required for future Air Force systems. The focus is currently on growth and use of semiconductors, magnetic alloys, and specialized dielectrics in bulk structures, heterostructures, quantum wells, superlattices, quantum wires, and quantum dots. Research on specialized nano-structures and meta-materials with clearly advanced electronic device implications is encouraged. Proposals are sought for significant advances in these areas, or expansion to novel application of materials with estimates comparing potential improvements to present capabilities and the impact on Air Force capabilities. Multifunctional materials which combine optical, electronic, ferromagnetic and/or piezoelectric properties are also of great interest.

Novel fabrication methods, in-situ and ex-situ characterization methods, and innovative substrates and materials that increase the integration density, or fill factor and efficiency are of significant interest, as well as advanced optoelectronic and electronic materials that will provide the building blocks for advances in laser and sensor applications and related components.

Compound semiconductors, heterostructures and other such materials are the foundation of new generations of wavelength-diverse, high sensitivity detectors; lower power consumption, high-efficiency electric lasers; as well as related multi-level functional devices and concepts. Prospective ferromagnetic semiconductor systems can open new windows on sensor and device development. The functional understanding of properties of spintronic materials would become the foundation for subsequent device development. All of these materials provide the properties necessary for improved performance and sensing capabilities for future Air Force systems.

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11. Optoelectronics: Components, Integration and Information Processing and Storage

This program supports Air Force requirements for information dominance by increasing capabilities in image capture; processing, storage, and transmission for surveillance, communications and computation; target discrimination; and autonomous navigation. In addition, high bandwidth interconnects enhance performance of distributed processor computations that provide real-time simulation, visualization, and battle management environments. Further important considerations for this program are the airborne and space environment in which there is a need to record, read, and change digital data at extremely high speeds. Four major areas of interest include Components and Information Processing, Nanophotonics, Compact Terahertz Sources and Detectors, and Optical Buffering and Storage.

The thrusts in components and information processing include investigations in two affiliated areas: (1) the development of optoelectronic devices and supportive materials and processing technology, and (2) the insertion of these components into optoelectronic computational, information processing and imaging systems. Device exploration and architectural development for processors are coordinated; synergistic interaction of these areas is expected, both in structuring architectural designs to reflect advancing device capabilities and in focusing device enhancements according to system needs. Research in optoelectronic or photonic devices and associated optical material emphasizes the insertion of optical technologies into computing, image-processing, and signal-processing systems. To this end, this program continues to foster interconnection capabilities, combining arrays of sources or modulators with arrays of detectors, with both being coupled to local electronic or potentially optical processors. Understanding the fundamental limits of the interaction of light with matter is important for achieving these device characteristics. Semiconductor materials, insulators, metals and associated electromagnetic materials and structures are the basis for the photonic device technologies. Numerous device approaches are part of the program as are techniques for optoelectronic integration.

System-level investigations incorporate these devices into processing architectures that exploit their demonstrated and envisioned attributes and determine appropriate problem classes for optical and optoelectronic approaches. The computational advantages and proper use of parallelism provided by optical implementations continue to guide architecture development. Computer interconnections continue to encounter increasing difficulty in signal transmission constrained by wire-crossing layout restrictions, electromagnetic interference, and cross-talk impediments that may be circumvented by optical interconnect approaches. Alternatively, another program thrust emphasizes the use of the inherent, extremely high bandwidth of optical carriers by investigating systems that use multi-spectral data representations. Fabrication of optical structures has now evolved to a precision, which allows us to control light within etched nanostructures. As semiconductor fabrication has matured so too has the crystal growth of quantum “boxes” for localizing electronic states in semiconductors. The combined engineering of electronic and optical properties on the nanometer scale in semiconductors opens up several fruitful paths for advancing current and future technologies. The program is interested in the design, growth and fabrication of nanostructures that can serve as building blocks for nano-optical systems. The research goals include integration of nanocavity lasers, filters, waveguides, detectors and diffractive optics, which can form nanofabricated photonic integrated circuits. Specific areas of current interest include nanophotonics, use of nanotechnology in photonics, exploring light at the nanoscale, nonlinear nanophotonics, plasmonics & excitonics, sub-wavelength components, photonic crystal and negative index materials, optical logic, optical signal processing, reconfigurable nanophotonics, nanophotonics enhanced detectors, chip scale optical networks, integrated nanophotonics and silicon-based photonics. Coupled somewhat to these areas are optoelectronic solutions to enable practical quantum computing schemes plus novel approaches to nanopower such as thermoelectrics.

In bridging the gap between electronics and photonics the program also explores opportunities in terahertz (THz) technologies and its associated applications in non-destructive evalution, communications, navigation aid, and security. Diverse approaches have been taken to create THz sources and detectors over the 0.3 to 10 THz range. Desired are THz sources and detectors that are compact, efficient, solid-state devices capable of integration with other solid-state components. Integration of transmit and receive functions on the same chip is another goal. More specifically quantum well solutions are of highest interest.

To support next generation processor architectures, image processing and capture and new multi-media application software, computer data buffering and storage research is needed. As devices are being developed that emit, modulate, transmit, filter, switch, and detect multi-spectral signals, for both parallel interconnects and quasi-serial transmission, it is important to develop the capability to buffer, store, and retrieve data at the rates and in the quantity anticipated by these devices. Architectural problems are also of interest that include, but are not limited to, optical access and storage in memory devices to obviate capacity, access latency, and input/output bandwidth concerns. The program focuses partially on optical memory technologies that support page-oriented or holographic configurations in two or three dimensions. Also of interest has been the ability to slow, store, and process light pulses. Materials with such capabilities could be used for tunable optical delay lines, optical buffers, high extinction optical switches, novel image processing hardware, and highly efficient wavelength converters.

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12. Sensing, Surveillance, Navigation

This research activity is concerned with the systematic analysis and interpretation of variable quantities that represent critical working knowledge and understanding of the changing Battlespace. “Signals Communication” is a sub-area referring to the conveyance of information physically through a channel. Surveillance images are of special importance in targeting, damage assessment and resource location. Signals are either naturally generated or deliberately transmitted, propagated as electromagnetic waves or other media, and recaptured at the receiving sensor. Modern radar, infrared, and electro-optical sensing systems produce large quantities of raw signaling that exhibit hidden correlations, are distorted by noise, but still retain features tied to their particular physical origin. Statistical research that treats spatial and temporal dependencies in such data is necessary to exploit its usable information. An outstanding need in the treatment of signals is to develop resilient algorithms for data representation in fewer bits (compression), image reconstruction/enhancement, and spectral/frequency estimation in the presence of external corrupting factors. These factors can involve deliberate interference, noise, ground clutter, and multi-path effects. This AFOSR program application of sophisticated mathematical methods, including time-frequency analysis and generalizations of the Fourier and wavelet transforms, that deal effectively with the degradation of signaling transmission across a channel. These methods hold promise in the detection and recognition of characteristic transient features, the synthesis of hard-to-intercept communications links, and the achievement of faithful compression and fast reconstruction for audio, video, and multi-spectral data. New combinations of known methods of asset location and navigation are being tried, based on analysis and high-performance computation that bring a force-multiplier effect to command/control capabilities. Continued upgrade and reliance on Global Positioning System makes is critical to achieve GPS-quality positioning in situations GPS by itself is not sufficient. Ongoing research in Inertial and non-Inertial navigation methods (including optical flow and use of signals of opportunity) will bring location precision and reliability to a superlative level. Continuous improvement in its repertoire of signal processing and statistical tools will enable the Air Force to maintain its lead in Battlespace awareness through navigation and surveillance. Communications are what hold together the networked Infosphere and cost-effective systems innovations that enable phenomenal air power projection.

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Mathematics, Information and Life Sciences (NL)

The Directorate is responsible for research activities in mathematics, information and life sciences. A wide range of fundamental mathematical, information and computer sciences, biology, and behavioral research is supported to provide the Air Force with novel options to increase performance and operational flexibility. Although the program descriptions that follow are specific sub areas of interest, there is interest in exploring novel ideas that bridge the disciplines. Many critical research activities are multidisciplinary and involve support from the other scientific directorates within AFOSR. The interfaces between disciplines often provide the insights necessary for technological advances. Creativity is encouraged in suggesting novel scientific approaches for our consideration.

1. Bioenergy

The primary objectives of this program are to understand and improve the facility of certain microorganisms to produce biofuels—specifically molecular hydrogen and algal lipids—for use in fuel cells and airbreathing engines, and to utilize other complex or impure biofuels for use in compact power generation. The capacity to supply renewable hydrogen and jet biofuels on a macro-scale using biologically based systems will enable the military to power tanks, planes and ships at a predictable cost basis independent of foreign oil markets. On the other hand, microorganisms that produce electricity on the micro-scale using readily available complex or mixed biofuels could serve as portable compact power sources for such devices as remote sensors or future miniature unmanned air and land vehicles.

This program supports research that explores the biochemical and molecular processes found in certain oxygenic phototrophs, such as microaglae and cyanobacteria, which enable them to generate molecular hydrogen and lipid biofuels when supplied with only water, carbon dioxide and light. Knowledge of the physiological, biochemical and genetic factors involved in limiting and augmenting production of these biofuels will be used to bioengineer photosynthetic organisms whose generation of hydrogen and lipid biofuels will be both highly efficient and controllable. Basic research in photosynthetic biochemistry, hydrogenase enzymology, and lipid biosynthesis is viewed as essential in accomplishing these objectives and, eventually, in developing the biotechnology needed to generate renewable, carbon-neutral supplies of lipid-derived jet fuels and fuel-cell hydrogen.

This program also supports research to enable the development of biofuel cells, both microbial and enzymatic, that can convert complex and impure fuel sources into electrical energy at sufficiently high power densities to be useful in portable devices. The idea is that biofuel cells will sustain their power by utilizing a wide range of fuel sources from the environment, such as ambient carbohydrates and macromolecules. Development of self-sustaining microbial or enzymatic biofuel cells will require understanding certain basic fundamental issues, including optimizing current production under variable conditions, biological mechanical energy storage, electron and proton transfer reactions and kinetics between enzymes/microbes and the electrode surface, theoretical modeling of mass transport in model biofuel cells, novel electrode designs, and enzyme engineering for faster catalysis.

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2. Complex Networks

Network behavior is influenced at many levels by fundamental theories of information exchange in the network protocols developed. The Complex Networks program seeks to understand mathematically how such fundamental approaches to information exchange influence overall network performance and behavior. These mathematical approaches will then be used to assess the predictability and performance of heterogeneous types of Air Force networks that must provide reliable transfer of data in dynamic, hostile and high interference environments. There are many mathematical analogs to this type of network analysis in the natural and physical sciences including materials science and statistical mechanics, molecular and systems biology, quantum and wave propagation physics, decision and game theory to name just a few. We can exploit the mathematical analysis that characterizes such general network information exchange in our formulation of engineering approaches for data networks in areas such as information and communication theory, signal processing, and control theory. Examples of mathematical approaches include geometric and information flow methods, approaches in algebraic topology, algebraic geometry, differential geometry, topological and algebraic graph theory, random matrix theory, lattice theory, and dynamical systems theory. Advances in these mathematical methods will then enable specific ways to model, characterize, design, and manage Air Force networks and capture and predict the performance of these networks under many diverse conditions.

Thus methods of consideration in network modeling might include characterizing overall network performance by finding geometric descriptions of embedded parameters of network performance, specific analytic expressions for network behavior derived from inverse methods on network data, and divergence analysis of parameters characterizing one state of a network from another. Characterization of network behavior might include multi-scale and vector space analysis of networks, performance prediction of networks based on local convexity analysis, inference and estimation of networks through algebraic, graph theoretic, and Markov random field descriptions, and understanding of the robustness of given norms and metrics in representing network behavior. Design of networks might involve understanding the efficiency, scaling behavior, and robustness of methods of information exchange including those that use both self and mutual information paradigms. Management of networks may involve assessment of stability and convergence of network behavior for various network dynamical models including time evolution, wave propagation models, and phase transition of network states.

Typical awards could be $125-250K per year for individual investigators. Multidisciplinary team proposals also are encouraged and will be considered on a case by case basis. Projects that include collaboration with scientists in the Air Force Research Laboratory are encouraged.

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3. Computational Mathematics

This program seeks to develop innovative mathematical methods and fast, reliable algorithms aimed at making radical advances in modeling and computational science in areas crucial to the Air Force of the future. Research successes in this program enable the analysis, understanding, and prediction of complex physical phenomena, as well as the design and control of vital Air Force systems and processes. Proposals to this program should focus on fundamental scientific and mathematical innovations as well as demonstrate strong connections to applications of interest to the Air Force. Application areas of current interest are wide ranging and support the Air Force's future mission in air, space, and cyberspace. They include but are not limited to unsteady aerodynamics, plasma dynamics, propulsion, directed energy, information science, and biological materials, processes and systems. Research in this program also supports the national program in high performance computing.

Typically, the computational models in this program rely on numerical schemes that discretize a complex set of continuum mechanics equations – generally partial differential equations – that represent the physics of the particular problem. However, alternative computational models may be appropriate for some problems. To meet the computational challenges in simulating nonlinear, discontinuous, multi-physics and multi-scale problems of interest to the Air Force, we are examining numerical algorithms which include multi-scale and multi-physics approaches with particular emphasis on convergence, error analysis and adaptivity. Additionally, developing rigorous algorithms for efficient and robust multidisciplinary design and optimization as well as understanding and quantifying the effects of uncertainties in computational models are of increasing interest. This program develops and improves a variety of numerical methods in these areas, including high-order spatial and temporal algorithms, mesh-free, particle methods, high-order moving interface algorithms, stochastic and hybrid methods.

This program also has an increasing interest in some emerging, challenging and cross-disciplinary mathematical modeling and computational problems in biology and information science where enabling mathematical and computational innovations are urgently needed. For example, in biology these include extracting fundamental engineering design principles from a deeper understanding of successful biological systems and processes. Such problems arise in the investigation of new methods for harvesting energy, the design of new materials and sensors, as well as information fusion, to name just a few. In information science, the real-time analysis of massive amounts of streaming data from heterogeneous, distributed sources remains a challenging problem. New ultrafast reliable algorithms for exploratory data analysis are required as well as finding the right blend of analog, digital, and distributed computation. In this connection recent advances in computational harmonic analysis provide some hope. Progress in this arena will also be useful in scientific informatics and computational forensics and in the verification and validation process for many complex computational models of physical processes or systems.

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4. Information Fusion and Distributed Intelligence

Developing and maintaining situational awareness in complex and dynamic military scenarios increasingly demands collection and interpretation of information from vast sets of disparate sources. The automated systems should seek out the information they need to pose and update high-level, actionable conclusions by sensing their environments, mining distributed and heterogeneous data sources, running embedded simulations, and incorporating human input. This entails a spectrum of constituent challenges, including handling data of disparate types, at different scales of granularity, and with varying degrees of quantification, accommodating distributed and networked information gathering with constraints and costs on resources, achieving computational tractability to scale to large scenarios with immense data flows and real-time requirements. Other challenges include dealing with unconventional targets, such as viruses infecting computer networks, learning and reasoning to distill high-level knowledge and conclusions with known reliability from all pertinent information sources, formulating and executing queries to gather information needed to fill the gaps between the current state of knowledge and reliable, actionable conclusions.

This program supports the basic research behind these objectives and the requisite challenges. Rigorous foundational approaches that underpin the development of scalable algorithms with predictable performance are of particular interest. In this regard, we encourage proposal of ideas to develop mathematical representations of information that simultaneously support low-level quantitative data and high-level qualitative information, create scalable frameworks for inference and learning on such representations, define meaningful and computable metrics of utility and uncertainty for fused information, design algorithmic approaches that provide predictable performance in terms of these metrics, and finally, pioneer new methodology for adaptive information gathering that continually identifies gaps in actionable information and takes action to fill such gaps.
Heuristic approaches are also of some interest, provided they support broadly applicable methodology and lead toward solutions whose domains of effectiveness and reliability can be accurately characterized.

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5. Dynamics and Control

This program emphasizes the interplay of dynamical systems and control theories with the aim of developing innovative synergistic strategies for the design and analysis of controlled systems that enable radically enhanced capabilities for future Air Force applications. Proposals should focus on the fundamental science and mathematics, but should include connectivity to appropriate Air Force applications. These applications currently include information systems, as well as autonomous/semi-autonomous aerial vehicles, munitions, and space vehicles.

Some current research interests include adaptive control and decision making for coordinated autonomous/semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, networked environments; understanding how to optimally include humans in the design space; novel schemes that enable challenging multi-agent aerospace tracking in complex, cluttered scenarios; robust and adaptive non-equilibrium control of nonlinear processes where the primary objective is enhanced operability rather than just local stability; new methods for understanding and mitigating the effects of uncertainties in dynamical processes; novel hybrid control systems that can intelligently manage actuator, sensor, and processor communications in a complex, spatially distributed and evolving system of systems; sensor rich, data driven adaptive control; managing adversarial and stability issues for systems in cyberspace; applying control concepts motivated by studies of biological systems; and the control of unsteady fluid-structure interactions. In general, support for research in linear systems theory is declining, while interest in the control of complex, multi-scale, hybrid, highly uncertain nonlinear systems is increasing. Further, new mathematics in clear support of dynamics and control is of fundamental importance. In this regard, some areas of interest include, but are not limited to, stochastic and adversarial systems, partial and corrupted information, max-plus and idempotent methods, game theory, nonlinear control and estimation, and novel computational techniques specifically aimed at games, control and systems theory.

The dramatic increase in complexity of Air Force systems provides unique challenges for the Dynamics and Control Program. Meeting these challenges may require interdisciplinary approaches as well as deeper studies within single disciplines. Lastly, note that the Dynamics and Control Program places special emphasis on techniques addressing realistic treatment of physical applications, complexity management, semi-autonomous systems, and real-time operation in stochastic and adversarial environments.

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6. Mathematical Modeling of Cognition and Decision

This program supports research on high-order cognitive processes that are responsible for human performance on complex problem solving and decision making tasks. The overall objective is to understand these processes by developing and empirically testing mathematical or computational models of human attention, memory, categorization, reasoning, problem solving, learning and motivation, and decision making. We are especially interested in how humans adapt to information-rich environments that are uncertain, dynamically changing, and often adversarial in nature, and gain knowledge and expertise to make decisions with effectiveness and efficiency; as well as how deviations of human behavior in certain situations from optimality and rational analysis can be accounted for and exploited.

Research to elucidate core computational algorithms of the mind and brain, often posed as finding solutions to well-formulated optimization or statistical estimation problems, has proven to be particularly valuable in providing the benchmark against which human performance can be measured. Selected examples of such algorithms include (the list is not exhaustive): (1) reinforcement learning algorithms for planning and control in sequential decision making, where short and long term goals of an action are optimally balanced; (2) sequential sampling algorithms for trading between speed and accuracy in decision-making under time pressure, where optimal stopping rules take into consideration payoff for a prompt but inaccurate decision and cost for delaying it; (3) classification algorithms from supervised or semi-supervised learning, where optimal generalization from examples during categorization learning is achieved through regularizing the complexity of data-fitting models; (4) probabilistic graphical models and Bayesian algorithms for reasoning, inference and prediction, where prior knowledge and data/evidence are optimally combined, in hierarchical and even non-parametric settings. In relating such core algorithms to human cognition and performance, research projects should not only ascertain their descriptive validity and neural plausibility or feasibility, but also deepen our understanding of mathematical characterizations of principles of adaptive intelligence. To this end, the program welcomes proposals investigating mathematical foundations of machine learning algorithms including reproducing kernels, sparse representation and compressed sensing, variational inference, manifold learning, graph diffusion, etc. The program encourages bidirectional interactions between the machine learning community and mathematics experts in convexity/duality, function analysis, differentiable manifold, algebraic topology, etc.

This program also embraces traditional approaches in mathematical psychology, for example, algebraic approaches for axiomatic foundations of probability, utility (and its temporal discounting), and geometric or topological approaches to characterize similarity and scaling between stimuli in a multi-dimensional vector space or manifold. Cross-disciplinary teams with cognitive psychologists in collaboration with mathematicians, statisticians, computer scientists and engineers, operation and management science researchers, information scientists, econometricians and game theoreticians, etc., are encouraged, especially when the research pertains to common issues and when collaboration is likely to generate bidirectional benefits.

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7. Natural Materials and Systems

The goals of this multidisciplinary program are to study, use, mimic, or alter how natural systems accomplish their taskings. Nature has used evolution to build materials and sensors that outperform current sensors (for example, a spider's haircells can detect air flow at low levels even in a noisy background). This program not only wants to mimic existing natural sensory systems, but also add existing capabilities to these organisms for more precise control over their material production. The research will encompass four general areas: sensory mimics, natural materials, natural/synthetic interfaces, and physical mechanisms of natural systems under environmental distress.

Sensory mimetic research attempts to mimic novel sensors that organisms use in their daily lives, and to learn engineering processes and mechanisms for control of those systems. This program also focuses on natural chromophores and photoluminescent materials found in microbial and protein-based systems as well as the mimicking of sensor denial systems, such as active and passive camouflage developed in certain organisms addressing predator-prey issues.

The natural materials area is focused on synthesis of novel materials and nanostructures using organisms as material factories. The program also focuses on understanding the structure and properties of the synthetic materials. The use of extremophiles is added to address the development of materials not accessible due to environmental extremes. We are also interested in organisms that disrupt or deny a material's function or existence in some way.

The natural/synthetic interfaces area is focused on the fundamental science at the biotic and abiotic interface. The nanotechnology and mesotechnology sub-efforts are focused on surface structure and new architectures using nature's idea of directed assembly at to the nanoscale to create desired effects, such as quantum electronic or three dimensional power structures. The use of these structures is in the design of patterned and templated surfaces, new catalysts, and natural materials based-optics/electronics.

The "physical mechanisms of natural systems under environmental distress" area is focused on discovering and understanding basic natural mechanisms that could be used to either harden or repair soft material-based devices. This will enable the Air Force to employ biological systems with optimum performance and extended lifetimes. As protein and nucleic acid molecules are increasingly used as catalysts, sensors, and as materials, it will be necessary to understand how we can utilize these molecules in extreme environments, with the ability to regulate the desired function as conditions change, and to store the device for prolonged periods of time. Areas of interest include: the mechanisms for survival and protein stability in extremophilic archaea, fundamental studies of bacterial sporulation, and enzymatic engineering for faster catalysis in anti-material designs.

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8. Optimization and Discrete Mathematics

The program goal is the development of mathematical methods for the optimization of large and complex models that will address future decision problems of interest to the Air Force. Areas of fundamental interest include resource allocation, planning, logistics, engineering design and scheduling. Increasingly, the decision models will address problems that arise in the design, management and defense of complex networks, in robust decision making, in optimal control and dynamical systems and in artificial intelligence and information technology applications.

There will be a focus on the development of new nonlinear, integer and combinatorial optimization algorithms, including those with stochastic components. Techniques designed to handle data that are uncertain, evolving, incomplete, conflicting, or overlapping are particularly important.

As basic research aimed at having the broadest possible impact, the development of new computational methods will include an emphasis on theoretical underpinnings, on rigorous convergence analysis, and on establishing provable bounds for (meta-) heuristics and other approximation methods.

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9. Sensory Information Systems

This program coordinates multi-disciplinary experimental research with mathematical, neuromorphic, and computational modeling to develop the basic scientific foundation for understanding and emulating sensory information systems. Emphasis is on (a) acoustic information analysis and (b) sensory processing systems that enable 3D airborne navigation and control of natural flight. One program emphasis is to forge new capabilities in acoustic analysis, especially to enhance the intelligibility and usefulness of acoustic information. The primary approach is to develop and test principles derived from an advancing knowledge of auditory processes, especially cortical processes which may offer keys to understanding how human audition out-performs machine-based acoustic analysis. Included in this approach are efforts to model and control effects of noise interference, understand and prevent informational masking, enhance methods for automatic speech detection, classification, and identification, and enable efficient 3D spatial segregation of multiple overlapping acoustic sources. Signal analysis methods based upon purely statistical or other conventional “blind source” approaches are not as likely to receive support as are approaches based upon auditory system concepts that emphasize higher-level processes not yet fully exploited in algorithms for acoustic information processing. Examples of such higher-level approaches recently supported are time-domain (modulation) filtering, vocal tract/glottal pulse normalization, and spectro-temporal analysis based upon properties of cortical receptive fields. Although the program's grantees have built a rich tradition of technical innovation in the acoustics area, with many important engineering applications for the Air Force, as well as for other governmental entities and the commercial sector, this program's priority remains the advancement of the basic science that serves as a foundation for technical progress. The program is multidisciplinary, drawing upon expertise in areas such as computer and electrical engineering, neuroscience, and mathematics. Applicants are encouraged to develop collaborative relationships with scientists in the Air Force Research Laboratory (AFRL).

A second program focus is on natural information processing systems for airborne 3D spatial navigation, maneuvering, and flight control. Emphasis is on the discovery of fundamental mechanisms that could be emulated in very small, automated air vehicles (UAVs), yet have no current analogues in engineered systems. For example, the sensorimotor control of flight in many insects depends upon distributed multimodal sensors with rather direct outputs to motor neurons, with apparently no requirement for the animal to compute or to update an estimate of its dynamic state. Sensor fusion is ubiquitous, e.g., between mechanosensors and vision. However, very little is yet known about how this sensory information fusion is accomplished and used to regulate flight behavior. Recent AFOSR-funded efforts have included investigations of information processing in wide field-of-view compound eye optical systems, polarization sensing and the use of natural polarization control for target segregation, camouflage, and signaling, and mathematical modeling of invertebrate and bat sensorimotor systems for autonomous path selection, obstacle avoidance, and stealth intercept/avoidance of moving targets. All of these example areas link fundamental experimental science with neuromorphic implementations to generate and test hypotheses. The program is interested in the fundamental science of sensorimotor control of adaptive flight, especially sensory systems that enable autonomy in spatial navigation and efficiency in aerodynamic control. As in the acoustic areas described above, applicants are encouraged to develop collaborations with AFRL scientists.

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10. Collective Behavior and Socio-Cultural Modeling

We are interested in developing a basic research foundation for using computational and modeling approaches to study behavior of group and communities. This program seeks fundamental understanding of the interactions between demographic groups both to create understanding for technology developments for enhanced cooperation, such as operational decision making with coalition partners, and to explain and predict outcomes between competing factions within geographic regions.

This program encourages collaboration between social, behavioral, cognitive, and biological scientists with computational researchers in disciplines such as mathematics, computer science, modeling, artificial intelligence, control theory, and adaptive systems. Example topics include: (1) Exploring the structure of cultural knowledge, beliefs, and social norms either broadly, in factor models, or more narrowly, within the framework of a computational cognitive architecture; (2) Reasoning and decision-making processes in cultural context, including reasoning with uncertain information; (3) Self-organization and adaptation of culturally defined entities or groups, including models of group competitive and cooperative interactions; (4) Game-theoretic modeling of interactive agents with imperfect and incomplete information regarding other agents; (5) New approaches to automated reasoning about belief, knowledge, obligation, time, and preference; and (6) Characterization of interacting dynamics at multiple scales, from individual to nation-state.

We are also interested in exploring the fundamental constraints and limits of socio-cultural prediction and rigorous mathematical approaches that will help us assess this. What is the appropriate data upon which to base such models? What are the theoretical justifications for the models proposed? What can such models reasonably be expected to accomplish? How can the different ontologies and models of the various relevant disciplines best be integrated? To predict group behavior do we need to understand the effects of individual level cognition on group decision making and neuroscience correlates of socio cultural behavior? Are multi-level approaches required? How generalizable are socio cultural models to other sub populations? How should we validate such models?

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11. Systems and Software

The goal of this research program is to seek revolutionary approaches to the design, creation, and employment of complex software-intensive systems that meet future Air Force needs in the air, space, and cyber domains. The program seeks bold, new basic research that addresses the specification, design, analysis, verification, and continued evolution of such systems.

We are looking for innovative research in systems and software engineering to address the growing size and complexity of software in Air Force platforms. Rigorous mathematical abstractions and representations that allow us to analyze and understand the complex interactions between these systems and the dynamic physical environments in which they operate will be crucial to their development and employment.

An understanding of the human's role in these complex systems is essential, so we seek new theories for modeling and developing complex systems that have human and machine components. It is important to consider combined approaches that address the hardware, software, and human components of large-scale systems.

Development of large-scale, complex systems as envisioned by this program may require a new understanding of computation. Research in theory of computing is needed to ensure the principles underlying these systems have a strong scientific basis.

The key to building complex systems with the necessary flexibility is to ensure a deeper understanding of how their underlying architectures can enable or enhance system adaptability to quickly changing conditions. This program seeks to define the theoretical underpinnings that will eventually lead to rapid and dynamic composability of systems.

This program also seeks basic research in systems and software that will lead to easier and less expensive approaches to the development and employment of complex software-intensive systems.

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12. Information Operations and Security

The goal of this program is to enable development of advanced security methods, models, and algorithms to support future Air Force systems. Research is sought to meet the Information Operations challenges of Computer Network Defense (CND), Computer Network Attack (CNA) and the management of the cyber security enterprise.

The security of software and hardware in Air Force systems and the protection of information are important issues within this program. Developing the understanding and tools to build inherently secure software, hardware and systems of systems and to ensure the security of the vast amounts of information flowing through relevant networks and information spaces are goals of this program. The development of a Science of Security for software, hardware and systems of systems is the holy grail of this program.

Methods to identify deceptive information already in the system are of particular interest. The development of the mathematical foundations of system, software, hardware and network architectures with respect to their security, including key metrics, abstractions, and analytical tools is a critical issue. New approaches to detection of intrusion, forensics, active response and recovery from an attack on information systems, are needed. Attack attribution is of particular interest. These systems and the data that flows through them will be managed by policy. Security policy research is another area of high interest to this program. Basic research that anticipates the nature of future information system attacks is critical to the survivability of these systems. Research that leads to methods to discover malicious code already imbedded in software or hardware is a high priority.

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Discovery Challenge Thrusts (DCTs)

This section outlines cross-cutting multi-disciplinary topics that support the AFOSR's Discovery Challenge Thrusts (DCTs). Research efforts will consist of interdisciplinary teams of researchers with the skills needed to address the relevant research challenges necessary to meet the program goals. Proposers are highly encouraged to confer with the appropriate AFOSR program manager. White Papers briefly summarizing your ideas and why they are different from what others are doing are highly encouraged, but not required. Coordination with the Air Force Research Laboratory is also encouraged but not required.

Air Force program managers are listed by Sub areas below.

1. Integrated Multi-modal Sensing, Processing, and Exploitation

Description: The Air Force Office of Scientific Research is seeking basic research proposals to conceive adaptive multi-modal EO-RF sensor concepts in a 'performance-driven' context that addresses the challenging problems of detecting, tracking, and identifying targets in highly cluttered, dynamic scenes. 'Performance-driven' requires that the development of novel adaptive multi-modal sensing hardware concepts be closely coupled with concurrent developments in novel physics-based modeling and simulation of target scene phenomenology, environmental interactions, and breakthroughs in data processing and exploitation. An integrated approach allows for assessing the utility of combining different sensing modalities, utilizing associated novel fused-data processing schemes for the target and background scenes of interest. It is expected that each research effort will consist of an interdisciplinary team having the appropriate skills needed to address all of the relevant program research challenges.

Background: The premise of this research is that developing adaptive multi-modal sensors able to capture multiple electromagnetic observables (intensity, wavelength, polarization, and/or phase) in a time-resolved, 'staring' imaging format will provide dramatically enhanced detection and identification capability for extremely challenging military problems involving low contrast targets over broad areas in a highly dynamic scene. Battlefield sensing requirements include finding and tracking individuals of interest in populated urban areas, detecting activity and materials indicative of IED placement, and detecting and identifying threatening space objects at long ranges. Historically, military target recognition involved conventional military objects exhibiting unique spatial and spectral signatures that were generally isolated from densely populated areas. However, today's target recognition problems include discriminating a multitude of complex objects deeply embedded in urban areas, day and night, where the most common urban objects can have tactical significance, and achieving high detection probability is critical to mission success. Current-generation remote sensing methods (e.g., broadband FLIR) are limited in their ability to search and detect camouflaged targets in deeply-hidden or highly-cluttered backgrounds. Proven approaches for enhancing deeply-hidden, high-clutter target recognition includes utilizing multi- to hyper-spectral exploitation to improve signal-to-clutter ratio, and fusing multi-modal/multi-discriminant data, such as FLIR with SAR, to significantly reduce the amount of processing required for target classification, while simultaneously increasing target ID confidence.

However, limitations facing state-of-the-art multi- and hyper-spectral imagers include their 'step-stare' mode of operation (vs. desired staring mode) with revisit times that compromise detection of rapid moving targets, and their fixed-multi/hyper-band construct that can result in a tremendous amount of unimportant data for exploitation. Also, today's airborne hyper-spectral sensors are massive, typically 4-5X that of typical FLIR sensor units employed on tactical aircraft and weapons platforms, and they also require greater sensitivity than typical FLIR sensors to overcome the reduced photon count in narrow wavelength bands. Challenges confronting fusion of multi-discriminant data from single-mode detectors include handling translational registration errors, and a lack of robust, efficient feature extraction and correlation capabilities. To avoid the problems of unnecessary or unproductive sensor use and computations, it would be desirable to 'intelligently' select 'on-the-fly' an optimum subset of sensors and sensor settings that are most decision-relevant. While this will be very difficult, requiring breakthroughs in many sensing technology fronts, emerging innovations in semiconductor materials, device structures, and information sciences offer many interesting opportunities. A 'home-run' approach of interest is to innovate and develop a tunable multi-mode, vertically-integrated (common sensor package), large-format staring focal plane array to accommodate the dynamic sensing requirements dictated by the dynamic target scene. This would involve actively controlling sensor modes and settings to optimize information gathering in a knowledge-based manner with an identifiable selection criterion.

Basic Research Objectives: Program focus is on modeling and simulation of novel concepts for high-performance tunable multi-modal EO-RF focal plane arrays. This includes innovative physical device concepts and prediction of single- and fused-mode detector output signals, in coordination with first-order benefits analysis modeling of downstream data exploitation. Novel multi-modal detector designs should be guided by consideration of how they can optimally exploit the phenomenology of multi-modal target scene signatures; and of how multi-mode data streams can be fused and interpreted in novel and beneficial ways. For example, fused spectral-polarimetric signatures provide information on target material composition, surface characteristics, and 3-D shape simultaneously from a single sensor snapshot, where information in the spectral dependence on polarization state may not be evident from separated polarization and spectral data. To exploit these and other multi-mode opportunities, a closely coordinated multi-discipline research team, expert in detector device design, data fusion, and image processing and exploitation will be needed. While the primary focus of basic research is on innovative integrated multi-modal EO-RF detector device concepts, supportive analysis and understanding of downstream data exploitation utility will be essential. Sensing modalities of interest include spatial, spectral, polarimetric, radiometric, and temporal; wavelengths of interest span UV (0.2um) to RF (mm). The envisioned multi-modal device design should build from extensive developments in both passive and active sensing, but specifically address the basic research aspect of multi-modal integration into a common sensor package (e.g., detector array). The ultimate vision would be a starring sensor development approach that optimizes the collection of phenomena to support detection, tracking, and identification functionality. The sensor would capture, at the pixel level, the right combination of the pixel intensity spectrum, polarization state, time evolution (at high enough bandwidth to capture active ranging and vibration information), and possibly phase (field vs. intensity), and work cooperatively with other sensors to perform such functions. This sensor would be accompanied by a high fidelity model to confidently predict its performance as a function of sensor configuration and target and background characteristics. It is expected that proposals will describe cutting-edge efforts on basic scientific problems.

Program Scope: Single awards will typically be $250-300K per year, for 3 years. It is expected that each research effort will consist of an interdisciplinary team with the skills needed to address all of the relevant research challenges necessary to meet the program goals. Multi-university teaming is encouraged.

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2. Robust Decision Making

Description: The need for mixed human-machine decision making appears at all levels of Air Force operations and pervades every stage of Air Force missions. However, new theoretical and empirical guidance is needed to prescribe maximally effective mixtures of human and machine decision making in environments that are becoming increasingly complex and demanding as a result of the high uncertainty, complexity, time urgency, and rapidly changing nature of military missions. Massive amounts of relevant data are now available from powerful sensing systems to inform these decisions; however, the task of quickly extracting knowledge to guide human actions from an overwhelming flow of information is daunting. Basic research is needed to produce cognitive systems that are capable of communicating with humans in a natural manner that builds trust, are proficient at condensing intensive streams of sensory data into useful conceptual information in an efficient, real-time manner, and are competent at making rapid, adaptive, and robust prescriptions for prediction, inference, decision, and planning. New computational and mathematical principles of cognition are needed to form a symbiosis between human and machine systems, which coordinates and allocates responsibility between these entities in an optimal collaborative manner, achieving comprehensive situation awareness and anticipatory command and control.

Basic Research Objectives: In the area of a) data collection, processing, and exploitation technologies, there is a need for (a.1) attention systems for optimally allocating sensor resources depending on current state of knowledge, (a.2) reasoning systems for fusing information and building actionable knowledge out of raw sensory data, (a.3) inference systems for real time accumulation of evidence from conflicting sources of information for recognition and identification. In the area of b) command and control technologies, there is a need for (b.1) prediction systems for anticipating future behavior of adversarial agents based on past experience and current conditions, (b.2) rapid decision systems with flexible mixtures of man and machine responsibilities for reactive decision making under high time pressure, (b.3) robust strategic planning systems designed to allow for sudden changes in mission objectives, unexpected changes in environment, and possible irrational actions by adversaries. In the area of c) situation awareness technologies, there is a need for a human-system interface that (c.1) faithfully simulates the content of a human operator's working memory buffer and its update thus modeling the operator's dynamic awareness of inputs, constraints, goals, and problems, (c.2) optimizes information delivery, routing, refreshing, retrieval, and clearance to/from the human operator's awareness while utilizing the latter's long-term store for expert knowledge, memory and skills for robust decision making, (c.3) achieves symbiosis between human and machine systems in delegating and coordinating responsibilities for command and control decisions. In sum, new empirical and theoretical research is needed that provides a deeper understanding of the cognitive requirements for command and control by a decision maker with enhanced capability for situation awareness, allows for greater degree of uncertainty in terms of reasoning systems, produces greater robustness and adaptability in planning algorithms in dealing with unexpected interruptions and rapidly changing objectives, generates greater flexibility in terms of assumptions about adversarial agents, and gives clearer guidance for dealing with the complexities encountered in network-centric decision tasks. Projects that bridge the conceptual gaps between state-of-the-art statistical/machine learning algorithms or AI systems and human cognition and performance are particularly welcomed.

Program Scope: Typical awards could be $100-200K/year. It is expected that each research effort will consist of an interdisciplinary team formed from some combination of cognitive, computer, engineering, and mathematical/statistical scientists having the appropriate skills needed to forge new breakthroughs and make significant fundamental progress in this area.

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3. Turbulence Control and Implications

Description & Background: Under the AFOSR Discovery Challenge Thrust: Turbulence Control and Implications, AFOSR is pleased to solicit basic research proposals addressing the exploration, characterization, and modeling of fundamental processes in transitional and turbulent flows including, but not limited to, flow regimes characterized by either low Reynolds number or compressibility. Specific topics of interest for this BAA include the following.

Basic Research Objectives:
Effective actuation in flowfields relevant to AF systems that exploits flow physics (flowfield bifurcations, instabilities, etc.) and responds to a dynamic environment, with the following qualities:

- Robust, scalable actuation with adjustable authority as required by flow conditions. Both passive and active approaches may be considered.
- Characterization of the effectiveness of flow control methods, considering the influence of actuation rate and phase with respect to flow structures for tailored amplification or attenuation of disturbances.
- Development of robust, reliable sensors for flow control. Desired sensors should be adaptive, embeddable in the system, and possibly self-powered. Sensors should measure surface shear stress, pressure, or another physical quantity useful for inferring the flow state. Ideal sensors will be sensitive to very-low-amplitude disturbances with high spatial- and temporal-resolution and signal-to-noise ratio. Integration into limited-size wind-tunnel and flight experiments also must be considered.

High-fidelity models of transitional and turbulent flows incorporating flow control: Models should enable characterization and reliable prediction of physical phenomena associated with flow control, including transient and dynamic processes. Additionally, the models developed under this thrust should enable the development of reduced-order models for complete potentially-fielded flow control methods to facilitate design requirements and optimization without compromising other mission aspects. Research areas of interest under this topic include, but are not limited to, the following:

- Incorporation of multi-disciplinary analysis (e.g., aerodynamics, structures, materials, controls, sensing and actuation) including transfer of the proper physical quantities between sub-models for various disciplines.
- Integration of experimental, numerical and theoretical analyses.

- Development of advanced diagnostics required for characterization of the fundamental phenomena associated with flow control methodologies and for validation of numerical simulation tools.

Ideally, basic research efforts supported under this BAA will have relevance to a wide variety of potential applications. Air Force interest in the research solicited under this portion of the BAA includes, but is not limited to, potential application to the following flows:

- Compressible flow at high-subsonic, transonic or low-supersonic conditions for flight vehicles intended to efficiently operate across several speed regimes.
- Low-Reynolds number unsteady flows encountered by agile micro air vehicles.
- Transonic compressible flow over aero-optic turrets and cavities.
- Unsteady flows generated by high-lift systems, propulsion systems and landing gear responsible for significant acoustic emissions.

Program Scope: Both single- and multi-investigator proposals will be considered, with typical awards in the range of $100k-$300k.

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4. Space Situational Awareness

Description: The Air Force Office of Scientific Research is seeking basic research proposals to develop concepts and capabilities in the area of Space Situational Awareness (SSA). The goal is to detect, track, identify, and predict future capabilities, actions, and positions of all space objects at all altitudes with known accuracy and precision. This capability must include on-demand capacity for a highly-detailed characterization of individual space objects. SSA is more than the observation of the location and orbit of an object in space or the image of the object; it must include the ability to identify a satellite's capabilities and predict future operations and performance limits with known confidence. Therefore, we must be able to detect and understand the configuration and orientation of the satellite, and to detect and quantify maneuvers through changes in orbital state, object signature or telemetry, or characteristics of exhaust products. Prediction of the precise location of satellites and limitations to satellite operations requires knowledge of the space environment in near-real time and an understanding of the impacts of the space environment on space systems. Understanding of the physics of the environment is also required for accurate space environment forecast models.

Background: The challenge of SSA is to rapidly and accurately locate and comprehensively characterize every object in space with known confidence and in near real time, including its orbital parameters, physical state, purpose, and capabilities, to anticipate future actions based on real-time estimates of changes in state using all sources of possible information, and to appropriately and rapidly provide actionable, useful information. Predictive SSA helps to ensure the safe flight of satellites and to mitigate impacts from the space environment on operations. It provides the capability to identify, characterize and monitor all potential threats to friendly space assets and adversary space capabilities that pose a threat to friendly terrestrial forces and to make after-action assessments. SSA is long-term, immense in scope, continual in maintenance, and demanding in detail and timeliness.

Our space surveillance models, tools and sensors today have significant capabilities but are not adequate for the problems of the future. Space search and track requires observations over several orbits and may take from days to months for the identification of small and poorly resolved objects. In addition, data are limited by collection methods to specific orbital planes and local times for space-based observations and to specific locations for ground-based observations. Observations of small and distant satellites are especially problematic, as is the discrimination of these objects from space debris.

Knowledge of the space environment is an integral part of SSA. This knowledge is based on theoretical studies of a sparse data set of ground- and space-based remotely sensed data and *in situ* observations. Each observational modality has fundamental limits. Current models provide some capability of "nowcasting," but are limited by deficiencies in the physical understanding of the solar-terrestrial system. Much of the current forecasting capability is based on statistical or climatological models.

Basic Research Objectives: Successful proposals will propose research that addresses the current needs for space situational awareness described above. Priority will be given to proposals that address basic principles and fundamental limits of the following:

1. Non-imaging techniques leading to the identification and characterization of un-resolved space objects.
2. Innovative solutions to the inverse problems associated with characterization of non-resolved space objects.
3. Novel imaging or image processing methods to fundamentally decrease limitations on remote imaging of space objects
4. Predictive analyses of space objects that include characterizing, tracking and predicting the behavior of individual and groups of satellites using multi-source data.
5. The resolution of uncorrelated tracks and marginally detectable targets using sparse data.
6. The physical processes that control the formation and growth of ionospheric irregularities that impact communication, navigation and radar systems.
7. Phenomenology and basic physical processes leading to the understanding and forecasting of the neutral atmosphere and ionosphere.

Program Scope: The typical awards will be $150-250K per year for a three-year effort. Although it is expected that single investigator projects will be awarded, multidisciplinary team proposals will also be considered. Collaboration with researchers at the Air Force Research Laboratory is encouraged.

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5. Complex Networked Systems

Description: Air Force network systems today are faced with increasing demands on reliability and performance in many types of diverse protocols and configurations. The Complex Network Systems program therefore wishes to mathematically develop new network design approaches that result in performance being quantifiable and predictable over a wide range operating conditions rather than for static preconfigured conditions of policy or protocol. This program will thereby allow the Air Force to meet its challenges in operating high throughput networks in dynamic, unpredictable, and heterogeneous environments. In order to achieve this goal, we wish to establish mathematical strategies to quantify and manage network performance over all levels of functionality. Examples of such strategies may involve in distributed network estimation, optimization, and routing techniques, coding methods that can recover and route information even if protocols fail or are interrupted, and network analysis techniques that can detect or inference global network performance from many sparse distributed local measurements. These fundamental approaches to assessment and design of information exchange will then be used to improve overall network protocol performance, detection of and resilience to attack, scalability, routing performance, human network interaction, coding efficiency, resource utilization, throughput, latency, and reconfigurability as examples.

Basic Research Objectives: We thus wish to establish new methods to design and manage networks that assess and quantify performance at all levels and conditions of network operation. Areas of interest in ensuring predictable network performance include new methods for coding and quantization, new approaches for advanced rate distortion analysis, entropy, and error correction coding. We would also like a mathematical means of guaranteeing system performance in the context of dynamic network policies, human network interaction and decision-making, heterogeneous wired, wireless, and hybrid networks, and scalable numbers of users. At the networking level, areas of interest include new approaches to assessing the reliability of connections as a result of current and future protocol layering and buffering and cashing approaches, data retransmission, flooding, and latency. We would also like to develop new mathematical paradigms for quantifying centralized and decentralized routing performance and multiple access. In the area of physical transfer of data, we would like to understand new approaches to predictable space time coding, modulation, spectrum access, and physical routing mechanisms that are resilient to interference and attack.

Program Scope: Typical awards could be $125-250K per year for individual investigators. Multidisciplinary team proposals also are encouraged and will be considered on a case by case basis. Projects that include collaboration with scientists in the Air Force Research Laboratory are encouraged.

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6. Reconfigurable Materials for Cellular Electronic and Photonic Systems

Background: Background: In microelectronics, reconfigurable cellular electronic and photonic arrays (RCEPAs) have great potential of directly implementing complex systems as software-defined emulations, configuring pre-built (but uncommitted) logic, interconnect, switching, memory and other resources to perform a desired set of functions. The success in design, utility, and implementation of RCEPA systems is tightly coupled to the materials and geometries used in these basic device cells, as well as the choice of layout and interconnect of such device elements to serve as a switch array. Since these systems initially will be generic and be subsequently personalized for specific scenarios, operational emulations and functional personalization can be rendered quickly into useful systems, much faster than creating an equivalent custom integrated circuit. Architectures in hardware can now be software-defined. RCEPAs are malleable and, conceptually, infinitely reformable. Besides providing flexibility, reconfigurability also can provide resilience despite thousands of latent material and device point defects or faults, because the emulations are, in general, non-unique, so that circumlocution is possible. The impressive scale of integration in modern functional switching array systems with over 10^6 gates can lead to their displacing custom integrated circuits in many applications, depending on the physical technology being used to implement such a system.

Although such system implementations, such as field programmable gate arrays (FPGAs) which manipulate discrete, binary information are currently available, little work has been done to create architectures that exploit other forms of materials reconfiguration. A diversity of new concepts has emerged in reconfigurable materials, devices, circuits, and more elaborate forms of nano/micro-structural elements. These include phase-change, ferroic, magnetoresistive materials and devices, and micro- and nano-microelectro(opto)-mechanical (NEM/MEM/NOEM/MOEM) structures. These reconfigurable materials, devices, and structures generate a variety of interesting multi-state/continuum behaviors. Computational paradigms could be hybridized in principle and thereby be extended in performance. One can consider the in situ manipulation of electron, photon, phonon, magnon, magnetic domain, exciton, fluidic transport, modulation of aerodynamic surfaces, programmable attachment and assembly of components, and generation and reformation of wiring systems. New strategies can be studied and leveraged to exploit these alternate reconfigurability modalities in new types of architectures. In addition to investigating a “bottom-up” strategy based on material phenomenon physical change mechanisms, a simultaneous "top-down" research strategy is possible based on architectures and languages. These latter strategies can also provide logical starting points for new classes of reconfigurable systems that are inspired through cellular arrangements of primitive building blocks.

Objective: Identify and better understand new reconfigurable materials, switching device concepts, and the viability of developing RCEPA architectures, languages, and synthesis tools based on cellular arrangements of primitive building blocks. These building blocks can be MEMS-like, MOSFET-like, phase change materials-like, magnetic-domain-like, photon transmissive-like, spintronic-like, or any mechanism that enables an externally digitally controlled, rapidly-reversible change between two or more (up to continuum) well-defined states in a way that allows for a redundant easily programmable system.

Research Concentration Areas: Research proposals are expected to address ideas from reconfigurable phenomenologies that motivate systems-level concepts, suggesting a multi-disciplinary teaming approach. This work focuses on integrating reconfigurable device concepts into flexible, multi-functional configurations designed to operate in simple to program architectures. Research areas include but are not limited to:

• Identification, characterization, and optimization of new primitive reconfigurability mechanisms in materials and nano/micro-scale structures (e.g., NEMS/MEMS or photonic approaches) .

• New concepts for devices, materials, and mechanisms that lend themselves to high performance and highly efficient RCEPA organization . Particular emphasis should be placed on prospective architectures that involve photonic write/electronic read, electronic write/photonic read, or photonic write/photonic read systems. **Improvements of existing and about-to-be introduced commercial and conceptual electronic write/electronic read approaches are not being solicited.**

• Extension of cellular networks with scale-free, random/amorphous (or other) network models to effectively harness the associated phenomenologies.

• Development of an understanding of the suitability of (homogeneous or heterogeneous) cellularity (two- and/or three-dimensional) as a theme for new configurations that aggregate these primitive cells;

• Development of suitable complementary concepts for expressive capacity, language constructs, metrics, and synthesis heuristics needed to mobilize large multi-dimensional ensembles of primitive cellular (or alternatively ordered) arrangements.

Interest domains include the emulation and interconnection of the following elements: (1) digital, (2) analog, (3) power, (4) microwave, (5) optical, (6) other sensing/actuation concepts, and mixtures of these domains.

Impact: New classes of reconfigurable electronics and photonics are expected to result in revolutionary expressions of pervasive morphability in warfighting systems. This morphability can lead to greater flexibility (and in some cases performance), resilience, and the ability to form systems more rapidly.

Program Scope: Typical awards will be in the range of $150K--$250K each year for three years. Collaborative projects which involve interaction between principal investigators at federally supported laboratories, such as AFRL, and/or FFRDCs coupled with an academic researcher will be considered. In this instance, a single joint proposal is appropriate, jointly vetted and supported by the management of the participating institutions. Interested parties should contact the topic research chief before submitting a brief "white paper." Formal proposals should be prepared only by invitation.

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7. Thermal Transport Phenomena and Scaling Laws

Description & Background: Discover new techniques for modeling, analyzing, and understanding thermal phenomena at multiple time and length scales in emerging and novel material systems, and exploiting these phenomena to design future materials and components with improved thermal transport properties (conduction, convection, and radiation). Improved thermal transport is vital to enable in future structural and electrical components the ability to operate at elevated performance levels while maintaining adequate reliability and lifetime.

Of special interest is investigating the potential for tailoring thermal transport properties utilizing breakthroughs in nano materials, structures, and devices. The end goal is to greatly improve our understanding of the thermal transport phenomena in bulk materials and heterogeneous material interfaces that are essential to help enable the future high temperature needs of critically enabling military technologies, such as high-speed processing & high power electronics and hypersonic thermal protection and propulsion systems. In particular, proposals in the following subject areas are encouraged:

Basic Research Objectives:
New materials (multi-phase and/or heterogeneous structures) that provide a wider spectrum of thermal conductivity and insulation, thermal capability -- possible areas of emphasis:

- Tuneable (dynamic) thermal conductivities of materials
- Biomimetic approaches

Multi-scale characterization and modeling tools – possible areas of emphasis:

- Tools to address complex coupled multiple physics phenomena (e.g. thermal, mechanical, magnetic, electric, etc)

- Robust models with increased fidelity and speed

Program Scope: Typical awards will be $125-250K. It is expected that single investigator projects will be awarded. Collaboration with researchers at the Air Force Research Laboratory are encouraged but not required. White papers are required and should be no more than 2 pages in length. White papers should be sent by email and must include a short project description, discussion of how the proposed research will advance fundamental scientific understanding and a proposed budget for 3-5 years. Successful whitepapers will be invited to submit full proposals.

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8. Radiant Energy Delivery and Materials Interaction

Goal: Understand and control the generation, propagation (particularly through complex media), scattering, and deposition of radiant energy at all wavelengths, intensities, and timescales. Explore the possibility that various natural media (dispersive, turbulent, random, etc) sustain certain EM waveforms more effectively than others as a result of their internal structure, geometric effects, and spatially heterogeneous dielectric and magnetic properties. Explore various manmade media (photonic bandgap materials, negative index materials, etc) for effects such as unidirectional propagation or total field trapping which might revolutionize the design/performance of a host of devices (antennas, baluns, delay lines, etc).

Science: Electromagnetic characterization (dispersion relation, index of refraction, etc) of complex media, both natural and manmade, needs to be pursued. For example, little is known concerning propagation events when the media has “fluctuations” resulting in fast temporal and/or spatial variation of the index of refraction. Examples include: turbulent media (atmospheres and boundary layers around fuselages), rustling foliage, clouds (due to Brownian motion of the water droplets), and urban environments (where multipath propagation limits communications and radar operation).

An example question is: “What is the detailed temporal and spatial statistical structure of the Doppler shift, if any, from fluctuating media?” It is anticipated that fluctuations, such as those occurring in clouds or the ionosphere, produce dephasing of transmitted signals/waveforms (resulting in such degradation as to prohibit imaging) as well as other unwanted artifacts and attempts at ameliorization are best served by fundamental understanding of the phenomena.

The above discussion leads in turn to the basic research challenge of identifying possible medium and target specific “optimal” waveforms (likely not CW if spatial resolution, provided by sufficient bandwidth, is the figure of merit) as well as spatial aperture distributions. The issue of optimal waveforms is a new time-domain direction for theorists studying Maxwell’s equations and is currently exemplified by waveforms called precursors which appear to be optimal for a large class of notional dispersive media (Debye, Lorenz, and Rocard-Powles).

Provide the underlying theory leading to the design of transceivers which can emit the above waveforms and identify the accompanying software paradigms which can intelligently deal with the non-CW nature of the returns. Also provide the underlying theory, which is anticipated to include a deeper understanding of various manmade media (such as photonic bandgap media and negative index media), leading to the design of electrically small antennas (on possibly exotic/complex substrates) having such attractive attributes as being highly directional, and having wide bandwidth. For example, there is no predictive method to anticipate a material's relationship between energy stored coherently and energy lost as heat. Construction of a microscopic theory would permit accelerated material design. Questions regarding conformal phased arrays (also on possibly exotic/complex substrates) include whether there is a fundamental relation between the minimum profile of such an array and its bandwidth or scan range. In addition, impedance matching from the signal source to the antenna is especially difficult in the wideband case. Developments made in antenna theory must be complemented with developments addressing impedance matching and improved design of baluns.

Pursue a deeper and more comprehensive understanding of ultrashort, high peak intensity laser pulses. Issues such as nonlinear propagation through the atmosphere (as well as through such obscurants as clouds) together with the novel nature of the light/matter interaction of such pulses (also important in materials processing scenarios) should be considered. Specific issues that merit basic research attention include filamentation control, energy deposition range control, propagation distance enhancement, ancillary production of THz radiation, and generation of plasma discharges in the atmosphere.

Carefully interrogate the Maxwell Semiconductor Bloch description of solid state lasers in order to lay the groundwork for the design/operation of coupled SSLs which could, when their individual chaotic outputs are suitably orchestrated and the thermal loads are suitably ameliorated, provide effective HEL performance. Other results flowing from basic research in MSB include novel THz production from semiconductors.

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10. Super-Configurable Multifunctional Structures

Background: The demands of real-time performance optimization for reconfigured missions require a variety of aerospace platforms to obtain the capability of dramatically altering their shape, functionality or mechanical properties in response to the changes in surrounding environments or operating conditions. The most well-known example of this concept is “morphing” aircraft that can change their wing shape and thereby perform flight control without the use of conventional control surfaces or seams similar to what is found in nature. Morphing wing aircraft promises the distinct advantages of being able to fly multiple types of missions, to perform radically new maneuvers impossible with conventional control surfaces, and to provide a reduced radar signature. By extending the concept beyond the case of shape change in morphing wing aircraft, more complex forms of reconfigurable systems can be envisioned involving combined changes of shape, functionality and mechanical properties on demand such as utilized in bats, but on a more extreme scale. Examples of such reconfigurable multifunctional structures, referred hereafter as “super-configurable” structures, include: (a) morphing unmanned aerial vehicles (UAV) that are capable of efficiently loitering in a region for surveillance and then reconfiguring for a high-speed dash to engagement, and would require full integration of sensing, communication, actuation and propulsion capabilities into load-bearing structures for higher system efficiency, and (b) space-deployable systems enabling a notional asset delivered in compact form in the upper atmosphere and under extremely harsh loading conditions (such as Mach 6) and subsequently reconfigured to produce a multiple number of micro-UAV’s with sub-meter dimensions for surveillance operation in the lower atmosphere.

From current trends in the research area of morphing wing aircraft, it is evident that the practical realization of morphing structures is a particularly demanding goal with substantial research effort still required. This is primarily due to the need of any proposed structures to possess conflicting abilities to be both structurally compliant to allow configuration changes but also be sufficiently rigid to limit the aero-elastic divergence. On top of these requirements, the design of the morphing structures must take full account of the weight penalty and the power requirements for the control mechanisms to ensure an overall performance benefit. Complexity of the problems and conflicting requirements are expected to be even greater for the proposed super-configurable multifunctional structures involving combined changes of shape, functionality and mechanical properties. The design of these multifunctional structures depends on the mode of reconfiguration, the specific materials and geometries employed, the attachment mechanism between elements, and the location of the actuating elements. A diversity of new concepts has emerged not only in reconfiguration of structures, but also in adaptive materials or materials systems, sensors, actuators, signal transmitters, energy transduction mechanisms to power the reconfiguration process and etc. When these concepts are judiciously combined, they have the potential to impart new and unprecedented structural multi-functionality. The success of super-configurable multifunctional structures will also be dependent on: (a) the development of robust modeling and design tools, (b) a fundamental understanding of the complex and time-variant properties of the material and mechanization structure in diverse environments, (c) processing techniques to readily achieve a range of desired multifunctional structures with minimum alteration of weight, and (d) integrated control systems functioning in operating environments that can vary widely.

Objective: (a) To provide scientific basis for the development of new “morphing” aerospace platforms capable of altering their shape, functionality and mechanical properties in response to the changes in surrounding environments or operating conditions, and (b) to identify and better understand new basic research concepts for structural reconfiguration, adaptive materials, micro-devices for sensing, communication and actuation, energy transduction mechanisms and system integration that would establish aerospace platforms as reconfigurable multifunctional structures.

Research Concentration Areas: Proposals are expected to address research ideas for super-configurable multifunctional structures that are either motivated by the above-cited system level concept or similar operational environments. Due to the highly coupled nature of various research topics involved, multi-disciplinary teaming between co-recipients and interactions with other pertinent research and development efforts will be highly encouraged. Research areas include but are not limited to:

New adaptive materials or novel chemistry (such as reconfigurable granular/colloidal assemblies, shape memory composites, phase-change materials, multi-ferroic interactions, novel particle coupling in microvascular networks, in-situ synthesis of materials, reversible chemistry, surfaces with reversible adhesion) which may allow reversible modulation of mechanical or electromagnetic properties in effective manner.

- Energy efficient and light-weight means for distributed actuation of reconfigurable structures via the intelligent amplifications of materials with multi-scale kinematic elements, or cells, to produce a “mechanized” material systems with tailored deformation modes.
- New and further miniaturized micro-devices allowing greater flexibility in electronic functionality and full integration of sensing, communication, actuation and propulsion capabilities into load-bearing structures of UAV for higher system efficiency.
- Networking capability to sense external stimuli (such as wind gusts or changes in temperature) and provide feedback to the flight control system (such as morphing of the vehicle shape) in much the same way that biological tissue is replete with nerves and muscles to sense and interact with the environment.
- New triggering mechanisms for reconfiguration that may be distributed throughout the structures (rather than a single large actuation source) and entail minimal requirements of connection through embedded wiring and additional power.
- Utilization of thermal and kinetic energy from external heat and structural vibration in powering the reconfiguration process.
- Autonomic protection or defense of reconfigurable structures to high-threshold mechanical, thermal, and electromagnetic events via the use of the event energy to (a) trigger repair, (b) initiate mass flow, enhanced emission, reduced absorbance, or enhanced reflection, and (c) synthesize robust and passivating materials.

- Morphing load-bearing joints which allow motion to occur but efficiently carry primary aerodynamic loads during reconfiguration.
- Assessment of the system stability starting from a compact structure delivered in space-deployable configuration under harsh loading conditions (such as Mach 6) to subsequent transition to a micro-UAV in flight in the lower atmosphere and a potential means of enabling survival of structures.
- Processing and manufacturing sciences for the control of morphology, topography and spatial configuration of reconfigurable multifunctional structures at various structural levels
- Multifunctional design rules for the integration of materials, devices, structures, actuation mechanisms and aerodynamic constraints into a concise system. This requires a broad understanding of the individual components, but more importantly an understanding of the interactions between them.
- Modeling and simulation of multi-state/continuum behavior within physics-based framework with a potential to yield adaptive functionality.

Impact: New classes of reconfigurable multifunctional structures, which allow combined changes of shape, functionality and mechanical properties on demand, are expected to result in revolutionary breakthrough of pervasive morphing ability for a variety of aerospace platforms and defense systems. This can lead to greater operational flexibility (and in some cases performance), resilience, and the ability to form systems more rapidly.
Program Scope: Typical awards could be $125-250K. It is expected that single investigator projects will be awarded; however, multidisciplinary team proposals will also be considered. Projects that include collaboration with researchers at the Air Force Research Laboratory are encouraged.

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11. Prognosis of Aircraft and Space Devices, Components, and Systems

Description: Prognosis is a vision for a future capability that has the potential to dramatically increase the US Air Force operational capability with increased safety and reduces risk while minimizing life-cycle operational and support (O&S) cost. USAF strongly needs prognosis capability in their deployed aircraft and space platforms. Pervasive prognosis capability is needed at all levels of complexity, from material level through device and component levels up to system level. The prognosis capability should cover (1) quantitative assessment of individual performance by serial number or other unique identifier; (2) quick and responsive prediction of future performance capability and potential degradation; (3) delivery of actionable information to the operator and in-field commanders for taking corrective actions in a timely manner to insure mission completion while minimizing risk and operating cost. Performance assessment and prediction should be accurate and precise with defined confidence interval and quantified risk. in near real-time. This DCT will address the fundamental basic research challenges that need to be overcome in order to realize this long-term vision.

Background: The success of USAF air and space missions relies on the availability of complex systems that range from aircraft and space platforms to electronic devices and sensors that are expected to perform as needed with high confidence and reliability. Materials in USAF flight systems include a wide variety of metals, composites, polymers, and ceramics and combinations thereof ranging in forms from nanoscale, to films and coatings, to complex structural components and structural assemblies. These systems are asked to deliver the designed performance over extended periods of time and often beyond their original design life. Past design practices have relied on various methodologies for predicting in-field performance, from safe-life to damage tolerance to reliability-based metrics such as mean time between failures (MTBF) initially pioneered for electronic components. However, the initial design predictions of in-service performance have often been inadequate resulting in high costs for maintenance and repair, lack of availability or readiness, and in some cases loss of crew. Responses to these shortcomings include in-service inspection requirements such as for aircraft structural integrity (ASIP), mandated corrosion inspection and repairs, line replacement unit upgrades in avionics, and various reliability improvement programs. Great expense to the USAF occurs as a result of unnecessary and damaging inspections driven by these worst-case limits. Repetitive inspections are required to give a needed level of confidence that the damage state has not been missed. This methodology and mind-set has driven the entire field of component and system reliability for non-electronics to focus the research on end-of-life scenarios – large cracks and extensive corrosion, for example. In the field of electronics, line replaceable unit (LRU) actions are driven by an assumption that all LRUs behave at the level of the worst case. The situation has reached in which continuation of current practice leads to escalating and unsustainable O&S costs. Reusable space access platforms such as the national space transportation system orbiter end up requiring extensive ground time between missions to assure reliably the ability to launch the next mission for that platform. In addition, some space operations do not even allow for replacements!
To address this situation, a radical new approach is needed, in which individuals rather than statistical worst case scenarios must be considered. The ability is needed to predict by serial number or other unique identifier when a device or component, or system is reaching a state where it must be repaired, upgraded, or graciously replaced. This ability to perform individual predictions will replace the current practice which relies on system or fleet worst-case scenarios driven by the statistics of the lower tail of the reliability distribution. Such a revolutionary approach requires a diverse multitude of new capabilities ranging from science and technology know-how to fleet management and operations research. However, this DCT will focus on the fundamental basic research challenges that need to be addressed in order to make it possible.

Basic Research Objectives: Structural prognosis, as a vision for a future capability, is based on the integration of three concurrent and distinct categories: (1) multi-level sensing-based state awareness (material, structural, loading, operational environment, etc.); (2) material-level modeling and predictive simulation of damage progression; (3) structural-level modeling and predictive simulation of long-term load-bearing capability under operational loads and extreme environmental conditions. The integration of these three categories in a robust predictive-analysis tool will offer on–demand continuous assessment capability of upcoming structural state under evolving operational requirements and threat environment thus forming the basis of structural state prognosis. Many fundamental basic research challenges in each of these three categories exist; among the top ranked ones, we list the following:

(1) multi-level sensing-based state awareness (material, structural, loading, operational environment, etc.): (a) comprehensive characterization of local microstructural material evolution capable of providing a globally-selective and evolving “fingerprint” of the material state in support of damage evolution modeling; assessment of material state and damage progression through synergistic application and exploitation of NDE capabilities; (b) break-through sensors (light-weight, permanently installed, autonomous, durable, and reliable) for real-time sensing of material state and of external boundary conditions in extreme harsh environments. (c) capability to selectively sense of various evolving microstructural mechanisms contributing to key damage states in complex built-up structures and to overcome the challenge of detecting damage in inaccessible locations via large-scale interrogation and state sensing strategies.

(2) material-level modeling and predictive simulation of damage progression: (a) a set of local and global parameters that identify and describe damage in the complex engineered material systems needed for future flight structures; define the parameters (tensor? scalar?) that describe the state of damage in a anisotropic inhomogeneous material volume subjected to fatigue loading and identify how it could be possibly measured; (b) develop micromechanics-based material state and damage evolution models that can predict the variability within macro-mechanical damage models; determine the principal microstructural characteristics that can be related to remaining ultimate life and can be measured in the field; (c) develop fundamental material simulation methods capable of providing accurate predictions of material state, damage evolution, and ultimate life in the presence of material processing and component manufacturing variability, and loading path dependency.

(3) structural-level modeling and predictive simulation of long-term load-bearing capability under operational loads and extreme environmental conditions: (a) develop a robust and reliable multi-scale damage evolution model to predict damage growth from material initiation site to aircraft-level structural failure within the assumptions of USAF damage-tolerant structures; (b) evolve from the predictive modeling of crack nucleation and progression at a single site under single loading condition to the prediction of crack population nucleation and evolution at multiple sites and at various structural levels from component to the full assembly to give a prognosis of probability distribution functions of cracks and

of the coalescence of multisite crack damage for different damage nucleation mechanisms (mechanical fatigue, stress-corrosion; slightly atypical manufacturing anomalies); (c) develop integration strategies for fusing probabilistic state awareness information from global/local aircraft state sensing with damage evolution models and advanced probabilistic structural modeling to provide key sensitivity factors and engineering confidence intervals and achieve aircraft-level predictive modeling capable of near real-time hot spot identification and localization.

Program Scope: Two to four awards of $100-250k/year for 3 years are to be expected. The proposed research effort is expected to address fundamental breakthroughs in at least two of the three major research categories outlined above. Collaboration with scientists in the Air Force Research Laboratory (AFRL) is encouraged, but not required. White papers are encouraged as an initial and valuable step prior to proposal development. The white papers that are found of interest will be encouraged to develop into full proposals.

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Other Innovative Research Concepts

AFOSR always is looking for new research ideas and is open to considering unique and revolutionary concepts. If you have an exciting idea that doesn't seem to fit within one of the more specific topic descriptions of this Broad Agency Announcements (BAA) detailing our current technical programs, you may submit it under this section of the BAA.

AFOSR's goal is to create revolutionary scientific breakthroughs. This BAA seeks to invest in high payoff science and to identify challenging fundamental scientific problems relevant to the USAF in the 21st century. It is expected that proposals will describe cutting-edge efforts on basic scientific problems. Proposed research should investigate truly new and unique approaches and techniques that may enable revolutionary concepts with potentially high payoff relevant to Air Force mission.

Submission of a brief white paper (1-3 pages) describing the potential research effort is strongly encouraged prior to proposal submission. White Papers should briefly summarize your ideas, their scientific impact, and how they differ from what others are doing. Proposals not based on sound scientific or engineering principles will be quickly rejected. White papers will be reviewed by AFRL researchers familiar with the AF research interests in this area as well as suitable experts from academia. Copies of publications or student theses will not be considered as white papers.

Please include contact information including your mailing address, email address, telephone number, and fax number. This allows us to give prompt feedback to the proposer on the likelihood of a proposal being selected. We encourage you to send your white paper to:

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Education and Outreach Programs

The External Programs and Resources Interface Division (PIE) of the Air Force Office of Scientific Research (AFOSR), the International Office (IO), and two overseas detachments, AOARD and EOARD, are responsible for the management of several programs that improve science and engineering education in the U.S., and stimulate interactions between Air Force researchers and the broader international, as well as domestic, research community. Applications for these programs do not always require proposals but generally have specific deadlines, formats, and qualifications. Researchers applying for these programs should communicate with the point-of-contact (POC) listed in each program description.

United States Air Force National Research Council Resident Research Associateship (NRC/RRA) Program

The NRC/RRA Program offers postdoctoral and senior scientists and engineers opportunities to perform research at sponsoring Air Force laboratory sites. The objectives of this program are: (1) to provide researchers of unusual promise and ability opportunities to solve problems, largely of their own choice, that are compatible with the interests of the hosting laboratories; and (2) to contribute to the overall efforts of the Air Force laboratories.

Postdoctoral Research Associateships are awarded to U.S. citizens and permanent residents who have held doctorates for less than five years at the time of application. The awards are made initially for one year and may be renewed for a second year, and in some cases, a third year. A small number of associateships may be available for foreign citizens if laboratory funds are available.

Senior Research Associateships are awarded to individuals who have held doctorates for more than five years, have significant research experience, and are recognized internationally as experts in their specialized fields, as evidenced by numerous refereed journal publications, invited presentations, authorship of books or book chapters, and professional society awards of international stature. Although awards to senior associates are usually for one year, awards for periods of three months or longer may be considered. Renewals for a second and third year are possible. U.S. citizenship is not a requirement. Senior associates must be eligible for access to unclassified government information systems; eligibility is also subject to a successful background review and visit authorization that includes approved access to the Air Force base and its laboratory facilities.
Associates are considered independent contractors, and receive a stipend from the NRC while carrying out their proposed research. Annual stipends increase with additional years past the Ph.D. An appropriately higher stipend is offered to senior associates. Awardees also receive a relocation reimbursement and may be supported with limited funds for professional travel.

An on-line application is available at: **http://www.nationalacademies.org/rap**.

The program is currently administered by The National Research Council (NRC):
Research Associateship Programs (Keck568)
National Research Council
500 Fifth St, NW, Washington DC 20001
(202) 334-2760
E-mail: **rap@nas.edu**
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United States Air Force-Summer Faculty Fellowship Program (SFFP)

The SFFP offers fellowships to university faculty to conduct research at one of the Air Force research facilities in the summer. The objectives of the Summer Faculty Fellowship Program are to: (1) stimulate professional relationships among SFFP fellows and the scientists and engineers in AFRL Technical Directorates and other Air Force research facilities; (2) elevate the awareness in the U.S. academic community of Air Force research needs and foster continued research at SFFP fellows' institutions; and (3) provide the faculty opportunities to perform high-quality research at AFRL Technical Directorates and other Air Force research facilities.

SFFP fellows conduct research in collaboration with Air Force researchers for a continuous summer period of eight to twelve weeks at the Technical Directorates of the Air Force Research Laboratory, the US Air Force Academy, or the Air Force Institute of Technology. A final report is required at the completion of the summer appointment.

Applicants must be U.S. citizens or permanent residents and have an earned Ph.D. in science or engineering. Fellows must be eligible for access to unclassified government information systems; the fellowship award is subject to a successful background review and visit authorization that includes approved access to an Air Force installation and its laboratory facilities.

Fellows are awarded in different categories including both early career investigator and senior investigator. The stipend is based on the category. Each SFFP award is for one summer. The SFFP fellow may reapply for up to two additional summers, for a maximum of three summer awards.

An on-line application is available at: **http://www.asee.org/sffp/**.

The program is currently administered by The American Society for Engineering Education (ASEE):
American Society for Engineering Education
1818 N St, NW Suite 600
Washington DC 20036
http://www.asee.org/sffp

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Engineer and Scientist Exchange Program (ESEP)

The Engineer and Scientist Exchange Program (ESEP) is a DOD effort to promote international cooperation in military research, development, and acquisition through the exchange of defense scientists and engineers (S&E). A prerequisite for establishing the program is a formal international agreement, a Memorandum of Understanding (MOU), with each participant nation. Currently, DoD has signed ESEP agreements with Australia, Canada, Chile, Egypt, France, Germany, Greece, Israel, Italy, Japan, Norway, Poland, Portugal, Republic of Korea, Singapore, Sweden, Spain, The Netherlands, and the United Kingdom. The primary goals of ESEP are to:

- Broaden perspectives in research and development techniques and methods.
- Form a cadre of internationally experienced professionals to enhance USAF research and development programs.
- Gain insight into foreign research and development methods, organizational structures, procedures, production, logistics, testing, and management systems.
- Cultivate future international cooperative endeavors.
- Avoid duplication of research efforts among allied nations.

Air Force personnel are selected in a competitive process and are assigned for a 2-year tour. This may be preceded by 6 months of language training. Ad hoc placements (non- competitive) can be initiated by research sites; however, these are funded solely by their originators. Foreign S&E are usually assigned to US DoD organizations for 12 month periods; although assignments can be for shorter or longer duration. Each country bears the cost of supporting its participants in the program. AFOSR/IO is responsible for managing placement of all ESEP exchanges within the USAF, and is the "one face to the customer" for all USAF ESEP actions. SAF/IAPQ (Armaments Cooperation Division, Deputy Under Secretary of the Air Force, International Affairs), the executive agent, provides policy guidance. The Asian and European Offices of Aerospace Research and Development (AOARD/EOARD) are AFOSR field offices located in Tokyo and London. These offices act as overseas program liaison offices for US ESEP personnel working in Asia and Europe.

AFOSR/IO implements all actions for USAF participants once their selection is approved, and for the placement of foreign ESEP participants in Air Force organizations.

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Air Force Visiting Scientist Program

The AF Scientist Visiting Scientist Program provides outstanding Air Force scientists and engineers the opportunity to conduct full-time, "hands-on" research-related work in a leading U.S. University or industry laboratory for a period of up to 179 days on a temporary duty status funded by AFOSR. The university or industrial laboratory provides a letter of invitation, and makes facilities, equipment, and resources available. The host laboratory must be located in the United States. Typically the researcher is an Air Force scientist or engineer, at least at the GS-13 level or its military equivalent. The applicant must be currently active in his or her field of expertise, be widely recognized as an expert, and have a strong publication record. The applicant must write a project proposal, preferably not to exceed ten pages, but of sufficient depth and scope for evaluation by scientists at participating organizations. Hands-on laboratory research-related work is an essential program element. At the completion of the TDY, the visiting researcher is required to submit a written report detailing his or her experiences and results of the project. In addition, the visiting researcher may be required to give a seminar presentation at the Air Force laboratory or at AFOSR and to provide feedback for purposes of program assessment. Upon completion of the assignment the researcher returns to his or her Air Force laboratory.

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Window on Science (WOS) Program

The Window on Science (WOS) program facilitates technical interactions on fundamental research via direct contact between distinguished foreign researchers and Air Force Research Laboratory scientists and engineers. The WOS program sponsors foreign scientists and engineers to visit Air Force scientists and engineers at USAF sites typically within the U.S., but may also include other domestic or overseas locations. Although WOS visits are designed to be short-term in nature, visits to multiple sites are encouraged. In order to present their research to a greater audience, and to further Air Force interests, WOS visitors may also combine visits to Air Force R&D organizations with visits to Army, Navy, other government, university, or industrial facilities. The AFOSR international Detachment 1, the European Office of Aerospace Research and Development

(EOARD), London, United Kingdom, manages this program for Europe, Africa, the Middle East, and countries of the former Soviet Union. Detachment 2, the Asian Office of Aerospace Research and Development (AOARD), Tokyo, Japan manages this program for the remainder of Asia and the Pacific Rim. The International Office, AFOSR/IO, located within the main body of AFOSR, manages the program for the Americas. Participants in the WOS program will be foreign non-government researchers identified as subject matter experts by AFRL program managers, and whose visit benefits Air Force scientists and engineers. Travelers may be eligible to receive payment for their services; however, base clearance requests for unpaid non-government visitors can also be handled under the WOS program. Visitors will normally present seminars to discuss their work, which may or may not have been funded by the Air Force. The WOS program is not intended as a substitute for research programs, internships, associateships, or personnel exchange programs. The lead-time necessary to arrange a WOS visit is generally three months. A letter report from the traveler is required on completion of the visit.

EOARD: **http://www.london.af.mil/**
AOARD: **http://www.afosr.af.mil/International/int_aoard.htm**
International Office: **http://www.afosr.af.mil/international.htm**

Window on the World (WOW) Program

The Window on the World program provides outstanding Air Force scientists and engineers the opportunity to conduct full-time research at a foreign (non-government) host laboratory, or to perform full-time science and technology assessment activities for a period up to 179 days on temporary duty (TDY) status. The TDY is fully funded by AFOSR. Upon completion of the assignment the researcher returns to his or her Air Force activity. The host laboratory provides facilities, resources, and a letter of invitation. Typically the researcher is an Air Force scientist or engineer, at least at the GM/GS-13 level or its military equivalent. The researcher must be currently active in his or her field of expertise, be widely recognized as an expert, and have a strong publication record. Some knowledge of the language used by the researcher's host institution is desirable. The applicant must write a research proposal, preferably not to exceed 10 pages, but of sufficient depth and scope, so that it can be evaluated by the scientists at the participating organizations. The proposal must be endorsed by the applicant's Air Force Research Laboratory Technical Directorate Chief Scientist. Non-laboratory applicants, such as researchers at the Air Force Academy and Air Force Institute of Technology, should pass their proposals through the Chief Scientist of an AFRL Technical Directorate. Proposals that focus tightly on specific research problems or specific science and technology assessment topics will merit greater consideration than those that are of a survey nature. The researcher is required to submit a written report detailing his or her research effort and findings at the completion of the TDY. In addition, the researcher may be required to give a seminar-style presentation at the Air Force laboratory and/or at AFOSR and provide feedback for purposes of program assessment. Lead-time to set up a

"Window" visit is approximately four months. More detailed information is contained in the AFOSR Brochure, “International Window Programs.”

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National Defense Science and Engineering Graduate (NDSEG) Fellowship Program

The NDSEG Fellowship Program is a Department of Defense (DoD) fellowship program sponsored by Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Office of Naval Research (ONR), and the High Performance Computing Modernization Program (HPCMP). The DoD is committed to increasing the number and quality of our Nation’s scientists and engineers. The actual number of awards varies from year to year, depending upon the available funding. The NDSEG Fellows do not incur any military or other service obligations. NDSEG Fellowships are highly competitive and will be awarded for full-time study and research.

An awardee must be enrolled in a graduate program by Fall 2009; the graduate program must lead towards a Ph.D. Preference will be given to applicants in one, or closely related to one, of the following specialties: Aeronautical and Astronautical Engineering; Biosciences; Chemical Engineering; Chemistry; Civil Engineering; Cognitive, Neural and Behavioral Sciences; Computer and Computational Sciences; Electrical Engineering; Geosciences; Materials Science and Engineering; Mathematics; Mechanical Engineering; Naval Architecture and Ocean Engineering; Oceanography; and Physics.

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. Persons who hold permanent resident status are not eligible to apply. NDSEG Fellowships are intended for students at or near the beginning of their graduate study in science or engineering. Applications are encouraged from women, persons with disabilities, and members of ethnic and racial minority groups historically underrepresented in science and engineering fields, including African American, American Indian and Alaska Native, Native Hawaiian and Pacific Islander, and Hispanic persons.

The duration of an NDSEG Fellowship is thirty-six months cumulative starting in the fall of 2009. NDSEG Fellows may choose as their fellowship institution any accredited U.S. institution of higher education offering doctoral degrees in science or engineering. The availability of funds for the second and third years of each three-year award is contingent upon satisfactory academic progress.

In FY2009 NDSEG fellowships will provide stipends of $30,500, $31,000 and $31,500 in the first, second, and third years, respectively. Additionally, the NDSEG fellowship will pay the fellow's full tuition, required fees (not to include room and board) and minimum health insurance coverage offered through the institution, up to a total value of $1,000. Any excess insurance costs will be the responsibility of the fellow and can be paid using the stipend. The stipends will be prorated monthly based on a twelve-month academic year. If the fellow is not enrolled in an institutionally approved academic study and/or research during the summer months, financial support will not be provided. There are no dependency allowances. Persons with disabilities will be considered for additional allowances to offset special educational expenses.

An on-line application is available at: **http://www.asee.org/ndseg**.

This program is currently administered by the American Society for Engineering Education (ASEE):

NDSEG Fellowship Program c/o American Society for Engineering Education: 1818 N Street, N. W.
Suite 600 Washington, D. C., 20036 (202) 331-3516 Fax: (202) 265-8504 E-mail: **ndseg@asee.org**
http://www.asee.org/ndseg

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The Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE)

The ASSURE program supports undergraduate research in DoD relevant disciplines and is designed to increase the number of high-quality undergraduate science and engineering majors who ultimately decide to pursue advanced degrees in these fields. A strong U.S. science and engineering workforce is of clear interest to the DoD, as the capability of producing superior technology is essential for future national security.

The ASSURE program aims to provide valuable research opportunities for undergraduates, either through ongoing research programs or through projects specially designed for this purpose. Research projects should allow high quality interaction of students with faculty and/or other research mentors and access to appropriate facilities and professional development opportunities. Active research experience is considered one of the most effective ways to attract and retain talented undergraduates in science and engineering.

ASSURE projects must have a well-defined common focus that enables a research related experience for students. Projects may be based in a single discipline or academic department, or interdisciplinary or multi-department research opportunities with a strong intellectual focus. Each proposal should reflect the unique combination of the proposing institution's interests and capabilities. Applicants are encouraged to involve students in research who might not otherwise have the opportunity, particularly those from institutions where research programs are limited. Thus, a significant fraction of the student participants should come from outside the host institution. In addition, DoD is interested in strengthening institutions with limited research programs and especially encourages proposals that help to enhance the research infrastructure in predominantly undergraduate four-year institutions. Student participants must be citizens or permanent residents of the United States or its possessions.

The DoD ASSURE budget is $4.5 million annually. DoD expected ASSURE budget for new projects is approximately $1.5 million; this funding will be distributed among fifteen to twenty new ASSURE awards. DoD relevance will be considered in making funding decisions. Projects may be carried out during the summer months, during the academic year, or both. Sites may be proposed for durations of one to five years, with a three-year duration being typical.

DoD executes the ASSURE program collaboratively with the National Science Foundation (NSF) through its Research Experiences for Undergraduates (REU) Sites Program. DoD funded ASSURE sites will be selected by DoD scientists and engineers, but will be overseen by NSF as part of the NSF portfolio of REU Sites. There is no separate application for the ASSURE program; ASSURE funding is awarded through the NSF REU Sites Program.

Information about the NSF REU Program can be found at NSF Program Solicitation NSF 05-592: **http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517**. Applications are submitted through NSF Fastlane, **https://www.fastlane.nsf.gov/fastlane.jsp**.

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Special Programs

AFOSR provides the support for research and education through the following unique programs: The Small Business Technology Transfer Program (STTR); the Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) Program; and the University Research Initiative (URI) Program. Other support deemed appropriate by AFOSR, such as conferences and workshops, may also be sponsored.

Small Business Technology Transfer Program (STTR)

The primary objective of the AF STTR program is to involve small businesses in AF-relevant defense research, and enable them to commercialize their innovative technologies for the advancement of U.S. economic competitiveness. Specifically, the STTR Program is designed to provide an incentive for small companies, academic institutions, and non-profit research institutions, including federally-funded research and development centers (FFRDC), to work together to move emerging technical ideas from the laboratory to the marketplace.

Each STTR proposal must be submitted by a team that includes a small business (as the prime contractor for contracting purposes) and at least one academic or non-profit research institution, which have entered into a Cooperative Research and Development Agreement for the proposed effort. The STTR has two phases: Phase I efforts are up to $100,000 for a period not to exceed one year; and Phase II projects are two year efforts for amounts up to $750,000. More information regarding the AF STTR can be found at: http://www.sbirsttrmall.com/TopicPreRelease/Default.aspx.

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Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) Program

AFOSR HBCU/MI program consists of two main components:

AFOSR Core Research. Research proposals from HBCU/MI are reviewed by AFOSR Program Managers as part of their core program and may be funded from funds set aside by the AFOSR Director.

Department of Defense Infrastructure Support Program for Historically Black Colleges and Universities and Minority Institutions. The DoD has been providing grants for research and educational equipment at HBCU/MI. This program is administered by the Army Research Office, in collaboration with the AFOSR. Schools interested in this program should look for the Broad Agency Announcement that is usually published in October each year in the ARO webpage. The BAA is linked through the AFOSR Web site at **http://www.wpafb.af.mil/AFRL/afosr/**, under "Research Areas"; "Educational, Outreach and Special Programs" at **http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9304**.

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Young Investigator Research Program (YIP)

The AFOSR's YIP supports scientists and engineers who have received a Ph.D. or equivalent degrees in the last five years, and show exceptional ability and promise for conducting basic research. The objective of this program is to foster creative basic research in science and engineering; enhance early career development of outstanding young investigators; and increase opportunities for the young investigator to recognize the Air Force mission and related challenges in science and engineering.

Individual awards will be made to U.S. institutions of higher education, industrial laboratory or non-profit research organization where the principal investigator is U.S. citizen, national or permanent resident; employed on a full-time basis and hold a regular position. Each award will be funded at the $100K level per year for three years. Researchers working at the Federally Funded Research and Development Centers and DoD Laboratories will not be considered for the YIP competition. Specific information about YIP can be found at AFOSR Web site at **http://www.wpafb.af.mil/AFRL/afosr/**, under "Need Funding "; "Broad Agency Announcements"; "Young Investigator Program" under the current Broad Agency Announcement.

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University Research Initiative (URI) Programs

The URI programs are executed under the policy guidance of the Office of the Deputy Under Secretary of Defense for Laboratories and Basic Research, to enhance universities' capabilities to perform basic science and engineering research and related education in science and engineering areas critical to national defense. The URI programs include: the Defense Research Instrumentation Program (DURIP); the Multidisciplinary Research Program of the University Research Initiative (MURI); and the Presidential Early Career Awards for Scientists and Engineers. A short description of each program is listed below. Specific information on each URI program Broad Agency Announcement can be found on the AFOSR Web site at **http://www.wpafb.af.mil/AFRL/afosr/**, under "Research"; "Educational, Outreach and Special Programs" at **http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=8972**

Defense University Research Instrumentation Program (DURIP)

This program is administered through the Air Force Office of Scientific Research, the Army Research Office, and the Office of Naval Research. The DURIP program is for the acquisition of major equipment to augment current or develop new research capabilities to support research in the technical areas of interest to the DoD. The competition is open only to U.S. institutions of higher education, with degree granting programs in science, math, and/or engineering. Proposals to purchase instrumentation may request $50,000 to $1,000,000. Awards are typically one year in length. The BAA is linked through the AFOSR webpage AFOSR Web site at **http://www.wpafb.af.mil/AFRL/afosr/**, under "Need Funding"; "Broad Agency Announcements"; "DURIP".

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Multidisciplinary Research Program of the University Research Initiative (MURI)

This program is administered through the Army Research Office, the Office of Naval Research, and the Air Force Office of Scientific Research. The Multidisciplinary Research Initiative (MURI) supports university research efforts intersecting more than one traditional science and engineering discipline. Multidisciplinary research teaming not only accelerates research progress in areas particularly suited to this approach by cross-fertilization of ideas but also help to hasten the transition of basic research findings to practical application. By supporting team efforts, MURI complements other DoD programs that support university research through single-investigator awards. Awards are typically for a period of three years with two additional years possible as options. The new awards can be funded up to $1.5M per year, with the actual amount contingent upon the availability of funds, the specific topic, and the scope of the proposed work. The MURI is competed in specific research topics described in the current MURI announcement at **http://www.wpafb.af.mil/AFRL/afosr/** under "Need Funding"; "Broad Agency Announcements"; "MURI".

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The Department of Defense Experimental Program to Stimulate Competitive Research (DEPSCoR)

This program is executed under the policy guidance of the Office of the Deputy Under Secretary of Defense for Laboratories and Basic Sciences [ODUSD (LABS)] and administered through the Army Research Office (ARO), Office of Naval Research (ONR), and Air Force Office of Scientific Research (AFOSR) with the cooperation of the Experimental Program to Stimulate Competitive Research (EPSCoR) State Committees. The DoD, including AFOSR, plans to award fiscal year 2009 DEPSCoR appropriations through the DEPSCoR announcement.

DEPSCoR objectives are to: (1) enhance the capabilities of institutions of higher education ("universities") in eligible States to develop, plan, and execute science and engineering research that is competitive under the peer review systems used for awarding Federal research assistance; and (2) increase the probability of long term growth in the competitively awarded financial assistance that universities in eligible States receive from the Federal Government for science and engineering research. Consistent with these long term objectives of building research infrastructure, the DoD intends to competitively make multiyear awards for research and for associated graduate education of scientists and engineers in areas important to national defense. Universities in EPSCoR states/territories with degree granting programs in science, mathematics, and/or engineering are eligible to submit proposals for DEPSCoR research grants via their EPSCoR State Committee. Each EPSCoR State Committee will decide which DEPSCoR proposals will be forwarded to DoD. Eligible EPSCoR State Committees may submit a proposal package containing up to five (5) separately fundable proposals requesting support from DoD for a 36-month period. Within the state proposal package, all proposals must request a minimum of $250,000. To maximize the DEPSCoR program objectives, all DEPSCoR awards require a minimum non-federal cost sharing or matching of one-to-two (i.e., at least one dollar from State, institutional, and/or private sector sources to match each two dollars of DEPSCoR support being provided). Matching funds may support items such as salaries, indirect costs, operating expenses, or new equipment. Universities in 23 States and Territories are eligible to receive awards under this announcement.

STATES AND TERRITORIES CURRENTLY ELIGIBLE FOR DEPSCoR AWARDS

Alaska	Arkansas	Delaware	Louisiana	Idaho
Kansas	Kentucky	Maine	Montana	Nebraska
Nevada	New Hampshire	North Dakota	Oklahoma	Puerto Rico
Rhode Island	South Carolina	South Dakota	Tennessee	Vermont
West Virginia	Wyoming	U.S. Virgin Islands		

DEPSCoR research projects may address any of the technical areas listed in the respective Army, Navy, and Air Force' BAAs. BAAs and program descriptions are available on-line at the following addresses:

Air Force Office of Scientific Research: **http://www.wpafb.af.mil/AFRL/afosr/**, under ""Research"; "Educational, Outreach and Special Programs", "DEPSCoR".

U.S. Army Research Office: **http://www.aro.army.mil** , under "For the Researcher"; "Funding Opportunities,"
http://www.arl.army.mil/www/default.cfm?Action=6&Page=8 .

Office of Naval Research: **http://www.onr.navy.mil** , under ONR Science & Technology Departments, "Office of Transition (Code 03T), "Corporate Programs Division," **http://www.onr.navy.mil/sci_tech/3t/corporate/**.

Proposals to perform research in listed technical areas, or other areas important to national defense, will be considered. For detailed information regarding technical goals, individuals preparing proposals are advised to consult these announcements and to contact DoD program managers listed therein to explore possible mutual interest before submitting proposals.

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Presidential Early Career Award in Science & Engineering (PECASE)

The National Science & Technology Council (NTSC) sponsors PECASE awards to recognize outstanding young scientists and engineers at the outset of their careers. The PECASE embodies the high priority placed by the President on maintaining the leadership position of the US in science by producing outstanding scientists and engineers and nurturing their continued development. The Awards will identify a cadre of outstanding scientists and engineers who will broadly advance science and the missions important to the participating agencies.

The PECASE recognize some of the nation's finest scientists and engineers who, while early in their research careers, show exceptional potential for leadership at the frontiers of scientific knowledge during the 21st century. The Awards foster innovative and far-reaching developments in science and technology, increase awareness of careers in science and engineering, give recognition to the scientific missions of participating agencies, enhance connections between fundamental research and national goals, and highlight the importance of science and technology for the nation's future. The awards are conferred annually at the White House following recommendations from participating agencies.

To be eligible for the PECASE, an individual must be a US citizen, national, or permanent resident with no more than five years from receipt of the doctorate degree. Each award will be $200K per year for five years. AFOSR awardees will be selected from among highly qualified institute of higher education principal investigators to the AFOSR or former National Defense Science and Engineering Graduate (NDSEG) fellowship recipients. Candidates must hold tenure-track positions at U.S. universities. An individual wishing to apply for the program must be nominated by an AFOSR program manager and have a proposal that addresses Air Force research interests as described in the current AFOSR Broad Agency Announcement (BAA).

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Partnerships for Research Excellence and Transition (PRET)

The PRET Program is a university-based research program of excellence involving strong industrial ties to accelerate the transition of research results to industry. This program is designed to broaden the university base in support of defense research, strengthen university-industry cooperation, and improve U.S. competitiveness in areas of dual use. The goal of the program is to fund quality research and concurrently establish and support a deliberate exchange of scientific personnel between academia and industry. The research areas to be supported are provided under Sections I.a., I.b., and l.c. of this BAA document. As the program format is different from the other core programs, potential applicants are suggested to contact the program managers prior to the proposal preparation. Proposals will be evaluated on:

(1) The scientific and technical merits of the proposed research.
(2) The potential contributions of the proposed research to the mission of the Air Force.
(3) The proposed interface between university and industry for the purpose of transitioning the generated information; also significant, but of lesser importance are:
    a. The likelihood of the proposed effort to develop new research capabilities and broaden the research base in support of national defense;
    b. The proposer's key personnel qualifications, capabilities, related experience, facilities, or techniques or a combination of these factors that is integral to achieving Air Force Objectives;
    c. The proposer's and associated personnel's record of past performance; and
    d. The realism and reasonableness of proposed costs and availability of funds.

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All responsible, potential applicants from academia and industry are eligible to submit proposals. AFOSR particularly encourages proposals from small businesses, historically black colleges and universities, minority institutions and minority researchers. However, no portion of this BAA is set aside for a specific group. Cost sharing is encouraged but not required.

Conferences and Workshops

The Air Force Office of Scientific Research (AFOSR) understands that it is essential for the scientific community to maintain clear lines of communication for thorough and well- reasoned research to be accomplished. Support for conferences and workshops have proven to be an extremely valuable tool for AFOSR. They allow our technical managers the opportunity to receive current information in their respective disciplines. They also allow AFOSR the opportunity to inform the research community of the current thrust of AFOSR's programs. Conferences and workshops constitute a key forum for research and technology interchange. AFOSR accepts proposals from all recognized scientific, technical, or professional organizations that qualify for federal tax-exempt status. AFOSR’s financial support through appropriate financing vehicles for conferences and workshops is dependent on the availability of funds, program manager’s discretion, and certain other restrictions including:

- AFOSR support for a workshop or conference is not to be considered as an endorsement of any co-sponsoring organization, profit or non-profit.
- The subject matter of the conference or workshop is scientific, technical, or involves professional issues that are relevant to AFOSR’s mission of managing the Air Force basic research program.
- The purpose of our support is to transfer federally developed technology to the private sector or to stimulate wider interest and inquiry into the relevant scientific, technical, or professional issues relevant to AFOSR’s mission of managing the Air Force basic research program. Proposals for conference or workshop support should be submitted a minimum of six months Prior to the date of the conference. Proposals should include the following:

Technical Information:

- Summary indicating the objective(s) of the conference/workshop
- Topic(s) to be covered and how they are relevant to AFOSR’s mission of managing the Air Force basic research program
- Title, location, and date(s) of the conference/workshop
- Explanation of how the conference/workshop will relate to the research interests of AFOSR identified in Section III of the Broad Agency Announcement (BAA)
- Chairperson or principal investigator and his/her biographical information

- List of proposed participants and method (or copies) of announcement or invitation
- A note whether foreign nationals will be present

Evaluation Criteria For Conference Support:

Anticipated use of funds requested from AFOSR Proposals for conferences and workshops will be evaluated using the following criteria. All factors are of equal importance to each other:

- Technical merits of the proposed research and development.
- Potential relationship of the proposed research and development to the Department of Defense.
- The qualifications of the principal investigator(s) or conference chair(s).
- The realism and reasonableness of cost including proposed cost sharing and availability of funds.

Cost Information (In addition to information required on SF 424 (R&R) Budget forms):

- Total project costs by major cost elements
- Anticipated sources of conference/workshop income and amount from each source

If you have questions concerning the scientific aspects of a potential proposal to AFOSR for conference or workshop support, please contact the program manager listed in Section I of the BAA responsible for the particular scientific area of the conference/workshop.

II. Award Information

1. In Fiscal Year 2008, AFOSR managed funding support for approximately 1,600 grants, cooperative agreements, and contracts, totaling $400 million, to about 450 academic institutions and industrial firms. This included grants, cooperative agreements and contracts to academic institutions, non-profit organizations, and industry. Approximately $200M is available for support of actions awarded through this BAA process. Awards average $150,000 per year and may be proposed for up to five years. Awards may start any time during the fiscal year.

2. The Government anticipates the award of grants, cooperative agreements or contracts under this BAA.

III. Eligibility Information

All responsible, potential applicants from academia and industry are eligible to submit proposals. AFOSR particularly encourages proposals from small businesses, historically black colleges and universities, minority institutions and minority researchers. However, no portion of this BAA is set aside for a specific group. Proposals from Federal Agencies, including subcontracting/subrecipient efforts will not be evaluated under this BAA. Federal agencies should contact the primary POCs listed under each technical area to discuss funding through the internal Government procedures. Cost sharing is encouraged but not required.

IV. Application and Submission Information

1. Address to Request Announcement Package – This announcement may be accessed from the Internet at the Grants.gov web site (**http://www.grants.gov**). See 'For Electronic Submission' below. A copy of this BAA is also posted on FedBizOpps.gov (www.fbo.gov).

2. Marking of Proposals – As previously stated, AFOSR is seeking white papers and proposals that do not contain proprietary information. If proprietary information is submitted, AFOSR will make every effort to protect the confidentiality of the proposal and any evaluations. However, under the Freedom of Information Act (FOIA) requirements, such information (or portions thereof) may potentially be subject to release. If protection is desired for proprietary or confidential information, the proposer must mark the proposal with a protective legend found in FAR 52.215-1(e), Instructions to Offerors – Competitive Acquisition (Jan 2004), (modified to permit release to outside evaluators retained by AFOSR). Since the Government anticipates the award of either grants, cooperative agreements, or contracts, this statement is applicable to proposals for all three of these potential instruments.

3. Content and Form of Application Submission –

a. White Paper. Before submitting a research proposal, you may wish to further explore proposal opportunities. You can do this by contacting the appropriate AFOSR program manager who can provide greater detail about a particular opportunity; the program manager may then ask for a white paper. However, in your conversations with a Government official, be aware that only warranted contracting and grants officers are authorized to commit the Government.

If you prefer, or the program manager requests, you may submit a White Paper, which should briefly describe the proposed research project's (1) objective, (2) general approach, and (3) impact of Department of Defense (DoD) and civilian technology. The white paper may also contain any unique capabilities or experience you may have (e.g., collaborative research activities involving Air Force, DoD, or other Federal laboratory.)

The Program Manager may have additional guidelines regarding form and content of preliminary proposals. For additional information regarding White Papers, please see the AFRL BAA Guide for Industry at **http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=6790**.

White Paper Format

- Paper Size – 8.5 x 11 inch paper
- Margins – 1 inch
- Spacing – single or double spaced
- Font – Times New Roman, 10 or 12 point
- Copies –as discussed with the Program Manager
- Content – as described above

b. Full Proposals. The proposal may be submitted either electronically or in hard copy form, but not both. All proposers must include the SF 424 (R&R) form as the cover page. Unnecessarily elaborate brochures, reprints or presentations beyond those sufficient to present a complete and effective proposal are not desired. To convert attachments into PDF format, Grants.gov provides a list of PDF file converters at **http://www.grants.gov/help/download_software.jsp**

Full Proposal Format

- Paper Size – 8.5 x 11 inch paper
- Margins – 1 inch
- Spacing – single or double spaced
- Font – Times New Roman, 10 or 12 point
- Page Limitation – None, although unnecessarily elaborate proposals are not desirable.
- Attachments – submit in **PDF** format (Adobe Portable Document Format)
- Copies for hardcopy submissions – (one original, number of copies as discussed with the Program Manager)
- Content – as described below

(1) Advance Preparation For Electronic Submission - Electronic proposals must be submitted through Grants.gov. There are several one-time actions your organization must have completed before it will be able to submit applications through Grants.gov. Well before the submission deadline, you should verify that the persons authorized to submit proposals for your organization have completed those actions. If not, it may take them up to 21 days to complete the actions before they will be able to submit applications.

The process your organization must complete includes obtaining a Dun and Bradstreet Data Universal Numbering System (DUNS) number, registering with the Central Contract Registry (CCR), registering with the credential provider, and registering with Grants.gov. (Designating an E-Business Point of Contact (EBiz POC) and obtaining a special password called MPIN are important steps in the CCR registration process.) Go to **http://www.grants.gov/applicants/get_registered.jsp**. Use the Grants.gov Organization Registration Checklist at **http://www.grants.gov/section3/OrganizationRegCheck.pdf** to guide you through the process. To submit a proposal to through Grants.gov, applicants will need to download Adobe Reader. This small, free program will allow you to access, complete, and submit applications electronically and securely. To download a free version of the software, visit the following web site: **http://www.grants.gov/help/download_software.jsp**. Consult Grants.gov to ensure you have the required version of Adobe Reader installed. Should you have questions relating to the registration process, system requirements, how an application form works, the submittal process or Adobe Reader forms, call Grants.gov at 1-800-518-4726 or **support@Grants.gov** for updated information.

(2) Submitting the Application

(a) For Electronic Submission – Application forms and instructions are available at Grants.gov. To access these materials, go to **http://www.grants.gov**, select “Apply for Grants”, and then follow the instructions. In the Grants.gov search function, enter the funding opportunity number for this announcement (AFOSR-BAA-2009-1). You can also search for the CFDA Number 12.800, Air Force Defense Research Sciences Program. On the Selected Grant Applications for Download page, click on 'download' under the heading 'Instructions and Applications' to download the application package.

The funding opportunity will be listed multiple times. The funding opportunity number is identical for each listing. Select the Competition ID and Competition Title for the directorate specific to your area of interest to download the instructions and application.

If you are unsure which directorate and program manager is appropriate for your specific area of interest, select the Competition ID and Competition Title “Other” to download.

Due to high traffic volume, applicants are highly encouraged to submit applications early. Waiting until the due date and time may result in applications being late. Common closing dates include the first, fifteenth and last day of any month. In addition, Grants.gov is anticipating an unprecedented volume of heavy application traffic due to the increase in applications as a result of the Recovery Act. Potential applicants are reminded to plan accordingly. Also, please check Grants.gov prior to submission for any notices posted on Grants.gov offering alternate submission options as a result of system saturation. **Note: All attachments to all forms must be submitted in PDF format (Adobe Portable Document Format).** Grants.gov provides links to PDF file converters at this site: **http://grants.gov/agencies/asoftware.jsp#3**.

(b) For Hard Copy Submission – For hard copy submission, the original proposal and copies must be delivered to the attention of the program manager at the Air Force Office of Scientific Research at the following address:

AFOSR (Attn: Name of Program Manager)
Air Force Office of Scientific Research
875 North Randolph Street, Room 3112
Arlington VA 22203

In case of difficulties in determining the appropriate AFOSR addressee, proposals may be submitted to:

AFOSR/PKC
875 Randolph Street, Room 3112
Arlington VA 22203-1954

(c) SF 424 Research and Related (R&R) - The SF 424 (R&R) form must be used as the cover page for all electronic and hard copy proposals. No other sheets of paper may precede the SF 424 (R&R) for a hard copy proposal. A signed copy of the SF 424 (R&R) should be submitted with all hardcopy proposals. Complete all the required fields in accordance with the "pop-up" instructions on the form and the following instructions for the specified fields. To see the instructions, roll your mouse over the field to be filled out. You will see additional information about that field. For example on the SF424 (R&R) the Phone Number field says 'PHONE NUMBER (Contact Person): Enter the daytime phone number for the person to contact on matters relating to this application. This field is required.' Mandatory fields will have an asterisk marking the field and will appear yellow on most computers. In grants.gov, some fields will self populate based on the BAA selected. Please fill out the SF 424 first, as some fields on the SF 424 are used to auto populate fields in other forms. The completion of most fields is self-explanatory except for the following special instructions:

- **Field 2**: The Applicant Identifier may be left blank.

- **Field 3**: The Date Received by State and the State Application Identified are not applicable to research.

- **Field 7**: Complete as indicated. If Small Business is selected, please note if the organization is Woman-owned and/or Socially and

Economically Disadvantaged. If the organization is a Minority Institution, select "Other" and under "Other (Specify)" note that you are a Minority Institution (MI).

- **Field 9**: List Air Force Office of Scientific Research as the reviewing agency. This field is pre-populated in grants.gov.

- **Field 17**: Choose 'No'. Check 'Program is Not Covered By Executive Order 12372'.

- **Attachments: All attachments to all Grants.gov forms must be submitted in PDF format** (Adobe Portable Document Format). To convert attachments into PDF format, Grants.gov provides a list of PDF file converters at **http://www.grants.gov/resources/download_software.jsp**

A signed copy of the SF 424 (R&R) should be submitted with all hardcopy proposals.

(d) Certification: All awards require some form of certifications of compliance with national policy requirements.

For assistance awards, i.e., grants and cooperative agreements, proposers using the SF 424 (R&R) are providing the certification required by 32 CFR Part 28 regarding lobbying. (The full text of this certification may be found at http://www.wpafb.af.mil/shared/media/document/AFD-070817-127.pdf). If you have lobbying activities to disclose, you must complete the optional form **SF-LLL**, Standard Form – LLL, 'Disclosure of Lobbying Activities' in the downloaded PureEdge forms package.

If it is determined a contract is the appropriate vehicle, AFOSR will request additional documentation from prospective awardees. For contract awards, prospective contractors shall complete electronic annual representations and certifications at **http://www.bpn.gov/orca**. The representations and certifications shall be submitted to ORCA as necessary, but updated at least annually, to ensure they are current, accurate, and complete. These representations and certifications are effective until one year from date of submission or update to ORCA. In addition to the ORCA representations and certifications, prospective contractors shall complete the AFOSR Contract Certification which can be located at **http://www.wpafb.af.mil/shared/media/document/AFD-070820-024.doc**.

(e) Research and Related (R&R) Other Forms: The following other forms must be used for all electronic and hard copy proposals: R&R Senior/Key Person Profile form, R&R Project/Performance Site Locations form, R&R Other Project Information form and the R&R Budget form. The R&R Subaward Budget Attachment Form is required when subawardees are involved in the effort. The SF-LLL form is required when applicants have lobbying activities to disclose. PDF copies of all forms may be obtained at the grants.gov website.

(f) R&R Senior/Key Person Profile Form – Complete the R&R Senior/Key Person Profile Form for those key persons who will be performing the research. The principal purpose and routine use of the requested information are for evaluation of the qualifications of those persons who will perform the proposed research. For the principal investigator and each of the senior staff, provide a short biographical sketch and a list of significant publications (vitae) and attach it to the R&R Senior/Key Person Profile Form.

(g) R&R Project/Performance Site Locations Form – Complete all information as requested.

(h) R&R Other Project Information Form - Human Subject/Animal Use and Environmental Compliance.

Human Subject Use. Each proposal must address human subject involvement in the research by addressing Field 1 and 1a of the R&R Other Project Information Form. If Field 1 indicates "Yes", the Air Force must receive a completed OMB No. 0990-0263 form before a contract, grant, or cooperative agreement may be awarded to support research involving the use of human subjects. Attach the document to the R&R Other Project Information Form. If using grants.gov, a completed OMB No. 0990-0263 form shall be attached in field 11 of the R&R Other Project Information Form. The OMB No. 0990-0263 is available electronically at: **http://www.hhs.gov/ohrp/humansubjects/assurance/OF310.rtf**. Refer any questions regarding human subjects to Stephanie Bruce of the AFOSR Directorate of Mathematics, Information and Life Sciences at stephanie.bruce@afosr.af.mil.

Animal Use. Each proposal must address animal use protocols by addressing Field 2 and 2a of the R&R Other Project Information Form. If selected for award, additional documentation in accordance with Air Force standards will be required. Additional proposal guidance may be found at the AFOSR web site **http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9388**. Refer any questions regarding animal subjects to Stephanie Bruce of the AFOSR Directorate of Mathematics, Information and Life Sciences at stephanie.bruce@afosr.af.mil.

Environmental Compliance. Federal agencies making contract, grant, or cooperative agreement awards and recipients of such awards must comply with various environmental requirements. The National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. Sections 4321-4370 (a), requires that agencies consider the environmental impact of "major Federal actions" prior to any final agency decision. With respect to those awards which constitute "major Federal actions," as defined in 40 CFR 1508.18, federal agencies may be required to comply with NEPA and prepare an environmental impact statement (EIS) even if the agency does no more than provide grant funds to the recipient. Questions regarding NEPA compliance should be referred to the applicable AFOSR Program Manager. Most research efforts funded by AFOSR will, however, qualify for a categorical exclusion from the need to prepare an EIS. Air Force instructions/regulations provide for a categorical exclusion for basic and applied scientific research usually confined to the laboratory, if the research complies with all other applicable safety, environmental and natural resource conservation laws. Each proposal shall address environmental impact by filling in fields 4a through 4d of the R&R Other Project Information Form. This information will be used by AFOSR to make a determination if the proposed research effort qualifies for categorical exclusion.

Abstract - Include a concise (not to exceed 300 words) abstract that describes the research objective, technical approaches, anticipated outcome and impact of the specific research. In the header of the abstract include the program manager's name and directorate who should receive the proposal for consideration and evaluation. Attach the Abstract to the R&R Other Project Information form in field 6.

(i) R&R Other Project Information Form - Project Narrative Instructions

Project Narrative – Describe clearly the research including the objective and approach to be performed keeping in mind the evaluation criteria listed in Section V of this announcement. Also briefly indicate whether the intended research will result in environmental impacts outside the laboratory, and how the proposer will ensure compliance with environmental statutes and regulations. Attach the proposal narrative to R&R Other Project Information form in field 7.

Project Narrative - Statement of Objectives – Describe the actual research to be completed, including goals and objectives, on one-page titled Statement of Objectives. This statement of objectives may be incorporated into the award instead of incorporating the entire technical proposal. Active verbs should be used in this statement (for example, "conduct" research into a topic, "investigate" a problem, "determine" to test a hypothesis). It should not contain proprietary information.

Project Narrative - Research Effort – Describe in detail the research to be performed. State the objectives and approach and their relationship and comparable objectives in progress elsewhere. Additionally, state knowledge in the field and include a bibliography and a list of literature citations. Discuss the nature of the expected results. The adequacy of this information will influence the overall evaluation. Proposals for renewal of existing support must include a description of progress if the proposed objectives are related.

Project Narrative – **Principal Investigator (PI) Time.** PI time is required. List the estimate of time the principal investigator and other senior professional personnel will devote to the research. This shall include information pertaining to other commitments of time, such as sabbatical or extended leave; and proportion of time to be devoted to this research and to other research. Awards may be terminated when the principal investigator severs connections with the organization or is unable to continue active participation in the research. State the number of graduate students for whom each senior staff member is responsible. If the principal investigator or other key personnel are currently engaged in research under other auspices, or expect to receive support from other agencies for research during the time proposed for AFOSR support, state the title of the other research, the proportion of time to be devoted to it, the amount of support, name of agency, dates, etc. Send any changes in this information as soon as they are known. Submit a short abstract (including title, objectives, and approach) of that research and a copy of the budget for both present and pending research projects.

Project Narrative – **Facilities**. Describe facilities available for performing the proposed research and any additional facilities or equipment the organization proposes to acquire at its own expense. Indicate government-owned facilities or equipment already possessed that will be used. Reference the facilities contract number or, in the absence of a facilities contract, the specific facilities or equipment and the number of the award under which they are accountable.

Project Narrative – **Special Test Equipment.** List special test equipment or other property required to perform the proposed research. Segregate items to be acquired with award funds from those to be furnished by the Government. When possible and practicable, give a description or title and estimated cost of each item. When information on individual items is unknown or not available, group the items by class and estimate the values. In addition, state why it is necessary to acquire the property with award funds.

Project Narrative – **Equipment.** Justify the need for each equipment item. Additional facilities and equipment will not be provided unless the research cannot be completed by any other practical means. Include the proposed life expectancy of the equipment and whether it will be integrated with a larger assemblage or apparatus. If so, state who owns the existing apparatus.

Project Narrative – **High Performance Computing Availability.** Researchers that are supported under an AFOSR grant or contract, and meet certain restrictions, are eligible to apply for special accounts and participation in a full-spectrum of activities within the DOD high performance computing modernization program. This program provides, at no cost to the user, access to a range of state-of-the-art high performance computing assets and training opportunities that will allow the user to fully exploit these assets. Details of the capabilities of the program can be found at the following Internet address: **http://www.hpcmo.hpc.mil**. Researchers needing high performance cycles should address the utilization of this program to meet their required needs. AFOSR program managers will facilitate the establishment of accounts awarded.

(j) R&R Budget Form - Estimate the total research project cost. Categorize funds by year and provide separate annual budgets for projects lasting more than one year. In addition to the Research & Related Budget forms available on Grants.gov, the budget proposal should include a budget justification for each year, clearly explaining the need for each item. Applicants who enter a fee on Part J of the budget will not be eligible to receive a grant or cooperative agreement. Should a grant be awarded AFOSR will make payments to educational and non-profit recipients based upon a predetermined payment schedule. Payments will normally be made quarterly in advance of performance, based upon a spending profile which must be provided as part of the proposal. Payments should be limited to the amounts needed to conduct research during each respective period. Educational and Non-profit organizations shall submit a spending profile with their cost proposal. Attach the budget justification and/or spending profile to Section K of the R&R Budget form.
(**http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9388**).

4. Other Submission Requirements

Proposals submitted in whole or in part by electronic media (computer disk or tape, facsimile machine, electronic mail, etc.) ***will not be accepted*** (unless the full proposal is submitted electronically through Grants.gov).

5. Application Receipt Notices.

a. For Electronic Submission - The applicant's approved account holder for grants.gov will receive a confirmation page upon completing the submission to Grants.gov. This confirmation page is a record of the time and date stamp that is used to determine whether the proposal was submitted by the deadline. After an institution submits an application, Grants.gov generates a submission receipt via email and also sets the application status to "Received". This receipt verifies the Application has been successfully delivered to the Grants.gov system. Next, Grants.gov verifies the submission is valid by ensuring it does not contain viruses, the opportunity is still open, and the applicant login and applicant DUNS number match. If the submission is valid, Grants.gov generates a submission validation receipt via email and sets the application status to "Validated". If the application is not validated, the application status is set to "Rejected". The system sends a rejection email notification to the institution and the institution must resubmit the application package. Applicants can track the status of their application by logging in to Grants.gov.

b. For Hard Copy Submission – An applicant that submits a hard copy proposal to AFOSR will receive an email from the agency approximately ten days after the proposal due date to acknowledge receipt of the proposal and provide the agency's assigned tracking number. The email is sent to the authorized representative for the applicant institution.

6. Submission Due Dates and Times. This is an open-ended BAA, thus, this announcement will remain open until replaced by a successor BAA. Proposals may be submitted at any time during that period. For additional information regarding the BAA process please refer to the AFRL BAA Guide for Industry at **http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=6790**.

V. Application Review Information

AFOSR's overriding purpose in supporting this research is to advance the state of the art in areas related to the technical problems the Air Force encounters in developing and maintaining a superior Air Force; lowering the cost and improving the performance, maintainability, and supportability of Air Force weapon systems; and creating and preventing technological surprise.

Proposals submitted under this BAA are evaluated through a peer or scientific review process. If selected for contract award, evaluation will be on a competitive basis according to Public Law 98-369, Competition in Contracting Act of 1984, 10 USC 2361, and 10 USC 2374. If selected for grant/assistance instrument award, evaluation will use merit-based competitive procedures according to DoDGARS citation of 32 C.F.R Sec 22.315. Proposals may be evaluated by program managers at EOARD/AOARD and the appropriate AFRL Technology Directorates. Additionally, proposals may be evaluated by outside evaluators retained by AFOSR which may include support contractor personnel. Employees of commercial firms under contract to the Government may be used to administratively process proposals. These support contracts include nondisclosure agreements prohibiting their contractor employees from disclosing any information submitted by other contractors. Proposals submitted for Special Programs listed in Section I shall be evaluated under criteria as specified in their description. Subject to funding availability, all other proposals will be evaluated under the following two primary criteria, of equal importance, as follows:

1. Technical merits of the proposed research and development.
2. Potential relationship of the proposed research and development to the Department of Defense

Other evaluation criteria used in the technical reviews, which are of lesser importance than the primary criteria and of equal importance to each other, are:

1. The likelihood of the proposed effort to develop new research capabilities and broaden the research base in support of U.S. national defense.

2. The proposer's, principal investigator's, team leader's, or key personnel's qualifications, capabilities, related experience, facilities, or techniques or a combination of these factors that are integral to achieving USAF objectives.
3. The proposer's and associated personnel's record of past performance.
4. The realism and reasonableness of proposed costs.

Additional administrative information regarding submission of applications is contained in Section VIII below. The technical and cost information will be analyzed simultaneously during the evaluation process.

For conference support, please see the evaluation criteria listed under the heading of "Conferences and Workshops" under Section I of this announcement.

Proposals may be submitted for one or more topics or for a specific portion of one topic. A proposer may submit separate proposals on different topics or different proposals on the same topic. The U.S. Government does not guarantee an award in each topic area. Further, be advised that as funds are limited, otherwise meritorious proposals may not be funded. Therefore, it is important that proposals show strength in as many of the evaluation area as practicable for maximum competitiveness.

VI. Award Administration Information

1. Award Notices.

Should your proposal be selected for award, the principal investigator will receive a letter from the Technical Directorate stating this information. This is not an authorization to begin work. Your business office will be contacted by the grant or contracting officer to negotiate the terms of your award.

2. Reporting Requirements.

Grants and cooperative agreements typically require annual and final technical reports, financial reports, and final patent reports. Contracts typically require annual and final technical and patent reports. Copies of publications and presentations should be submitted.

Additional deliverables may be required based on the research being conducted.

VII. Agency Contacts

Should you have questions about a technical research area, contact the program manager listed for the research topic areas listed in Section I. Should you have questions about the BAA or procedures for submission of a proposal, please email **afosr.baa@afosr.af.mil**.

** Important Notice Regarding Questions of a Business Nature **
All questions shall be submitted in writing by electronic mail.
Questions presented by telephone call, fax message, or other means will not be responded to.

VIII. Additional Information

1. The cost of proposal preparation in response to this Announcement is not considered an allowable direct charge to any resulting award. Such cost is, however, an allowable expense to the normal bid and proposal indirect cost specified in FAR 31.205-18, or OMB Circular A-21, Cost Principles for Educational Institutions or OMB Circular A-122, Cost Principles for Nonprofit Organizations.

2. Every effort will be made to protect the confidentiality of the proposal and any evaluations. The proposer must mark the proposal with a protective legend in accordance with FAR 52.215-1(e), Instructions to Offerors – Competitive Acquisition (Jan 2004), if protection is desired for proprietary or confidential information.

3. Offerors are advised that employees of commercial firms under contract to the Government may be used to administratively process proposals. These support contracts include nondisclosure agreements prohibiting their contractor employees from disclosing any information submitted by other contractors.

4. Only contracting or grants officers are legally authorized to bind the government.

5. AFOSR documents are available on the AFOSR website at **http://www.wpafb.af.mil/AFRL/afosr/**.

6. Responses should reference Broad Agency Announcement AFOSR-BAA-2009-1.

7. Prospective awardee shall be registered in the CCR database prior to award, during performance, and through final payment of any award resulting from this announcement. Offerors may obtain information on registration and annual confirmation requirements via the Internet at **http://www.ccr.gov** or by calling 1-888-227-2423, or 269-961-5757.

8. AFOSR expects the performance of research funded by this announcement to be fundamental. DoD Directive 5230.24 and DoD Instruction 5230.27 define contracted fundamental research in a DoD context as follows:

   “Contracted Fundamental Research. Includes [research performed under] grants and contracts that are (a) funded by budget Category 6.1 ("Research"), whether performed by universities or industry or (b) funded by budget Category 6.2 ("Exploratory Development") and performed on-campus at a university. The research shall not be considered fundamental in those rare and exceptional circumstances where the 6.2-funded effort presents a high likelihood of disclosing performance characteristics of military systems or manufacturing technologies that are unique and critical to defense, and where agreement on restrictions have been recorded in the contract or grant."

9. Indirect Cost Limitation for Basic Research Awards Notices:

The purpose of this notice is to make potential proposers aware of the Indirect Cost Limitation for Basic Research Awards set forth in Section 8115 of the Department of Defense Appropriations Act, 2008 (P.L. 110-116). Section 8115 of the DoD Appropriations limits payments of negotiated indirect cost rates on contracts, grants, and cooperative agrements (or similar arrangement), which are funded with FY 2008 Basic Research appropriations and are awarded on or after November 14, 2007, to not more than 35 percent of the total cost of the instrument. This limitation also applies to any new award made by another Federal agency to a non-Federal entity on behalf of the DoD using FY 2008 Basic Research appropriations.

The purpose of this notice is to make potential proposers aware of the Indirect Cost Limitation for Basic Research Awards set forth in Section 8109 of the Department of Defense Appropriations Act, 2009 (P.L. 110-329). Section 8109 of the DoD Appropriations limits payments of negotiated indirect cost rates on contracts, grants, and cooperative agreements (or similar arrangement), which are funded with FY 2009 Basic Research appropriations to not more than 35 percent of the total cost of the instrument. This limitation also applies to any new award made by another Federal agency to a non-Federal entity on behalf of the DoD using FY 2009 Basic Research appropriations.

KEY POINTS

- The restriction on payment of indirect costs applies to all FY 2008 or FY2009 Basic Research appropriations obligated by any award – i.e., procurement contract, grant, cooperative agreemnt, or any other obligational arrangement – to a non-Federal entity or awardee on or after 14 November 2007.

- The limitation on payment of indirect costs applies to an award entered into at the prime level only and does not flow down to subordinate instruments.

- For the restriction on payment of indirect cost as a percentage of total cost, “total cost” has the meaning given in the Govenrment-wide cost principles that apply to the particular awardee (2 CFR part 220, 225, or 230, or 48 CFR part 31). “Indirect costs” are all costs of a prime award that are Facilities and Administration costs (for awardees subject to the cost principles in 2 CFR part 220) or indirect costs (for awardees subject to the cost principles in 2 CFR part 225 or 230 or 48 CFR part 31.