

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

BAA-AFOSR-2014-0001

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This announcement remains open until superseded.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. While proposals overall may be submitted at any time, specific topic instructions may recommend proposal submission by specific dates IAW anticipated funding.

7. Additional Overview

The Air Force Office of Scientific Research (AFOSR) manages the basic research investment for the U.S. Air Force. 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 U.S. Air Force needs. Using a carefully balanced research portfolio, research managers seek to create revolutionary scientific breakthroughs 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 U.S. 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 proposals that do not contain proprietary information. We expect our research to be fundamental.

It is anticipated the awards will be made in the form of a grant, cooperative agreement or contract. AFOSR reserves the right to select and fund for award all, some, part 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 cost 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 U.S. Air Force 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 five scientific Departments: Dynamical Systems and Control (RTA), Quantum and Non-Equilibrium Processes (RTB), Information, Decision and Complex Networks (RTC), Complex Materials and Devices (RTD), and Energy, Power and Propulsion (RTE). The research activities managed within each Department are summarized in this section.

a. Dynamical Systems and Control (RTA):

The Dynamical Systems and Control Department leads the discovery and development of the fundamental and integrated science that advances future air and space flight. The broad goal of the division is to discover and exploit the critical fundamental science and knowledge that will shape the future of aerospace sciences. A key emphasis is the establishment of the foundations necessary to advance the integration or convergence of the scientific disciplines critical to maintaining technological superiority. A wide range of fundamental research addressing mathematics, materials, fluid dynamics, and structural mechanics are brought together in an effort to increase performance and achieve unprecedented operational capability. The division carries out its ambitious mission through leadership of an international, highly diverse and multidisciplinary research community to find, support, and fosters new scientific discoveries that will ensure future novel innovations for the future U.S. Air Force.

The central research direction for this Department focuses on meeting the basic research challenges related to future air and space flight by leading the discovery and development of fundamental science and engineering in the following research areas:

- 1) Computational Mathematics, Dr. Fariba Fahroo
- 2) Dynamics and Control, Dr. Fariba Fahroo
- 3) Flow Interactions and Control, Dr. Douglas Smith
- 4) Multi-Scale Structural Mechanics and Prognosis, Dr. David Stargel
- 5) Optimization and Discrete Mathematics, Dr. Fariba Fahroo
- 6) Test and Evaluation (T&E), Dr. Michael Kendra
- 7) Turbulence and Transition, Dr. Rengasamy Ponnappan

Research areas are described in detail in the Sub areas below:

1. Computational Mathematics

Program Description: This program seeks to develop innovative mathematical methods and fast, reliable algorithms aimed at making radical advances in computational science. Research

in computational mathematics underpins foundational understanding of complex physical phenomena and leads to capabilities for analysis and prediction of phenomena crucial to design and control of future U.S. Air Force systems and processes. Proposals to this program should focus on fundamental scientific and mathematical innovations. Additionally, it is desirable to frame basic research ideas in the context of applications of relevance to the U.S. Air Force which can serve simultaneously to focus the research and to provide avenues for transition of basic research outcomes into practice. Applications of current interest include, but are not limited to, unsteady aerodynamics, plasma dynamics, propulsion, combustion, directed energy, information science, and material science.

Basic Research Objectives: Research under this program has traditionally emphasized schemes that address the discretization and numerical solution of complex systems of equations, generally partial differential equations that arise from physics. Nevertheless, alternative phenomenological models and computational approaches are of interest, particularly in connection with emerging applications involving information and biological sciences.

To meet the formidable computational challenges entailed in simulating nonlinear, discontinuous, multi-physics and multi-scale problems of interest to the U.S. Air Force, the program is examining numerical algorithms that include multi-scale and multi-physics approaches with particular emphasis on convergence, error analysis, and adaptivity. A spectrum of numerical methods in these areas are being developed and improved within the scope of the program, including high-order spatial and temporal algorithms, mesh-free and particle methods, high-order moving interface algorithms, and hybrid methods. The other areas of interest are rigorous model reduction techniques with quantifiable fidelity for efficient and robust multidisciplinary design and optimization, scalable algorithms for multi-core platforms and also uncertainty quantification (UQ). The active areas of interest in UQ include development of high accuracy stochastic numerical methods, stochastic model reduction and long term time integration techniques. Given the emerging computing platforms, including multicore-based platforms with complex architectures, the program is considering fundamental research on the mathematical aspects of scalable solvers with emphasis on parallelism across scales, high-order discretization, and multi-level domain decomposition techniques.

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2. Dynamics and Control

Program Description: 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, including performance and operational efficiency for future U.S. Air Force systems. 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.

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 applications, complexity management, semi-autonomous systems, and real-time operation in stochastic and adversarial environments.

Basic Research Objectives: 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; and applying control concepts motivated by studies of biological systems. In general, interest in the control of large 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.

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3. Flow Interactions and Control

Program Description: The Flow Interactions and Control portfolio supports basic research into the motion and control of aerodynamic shear flows, including the interactions of these flows with rigid and flexible surfaces. The portfolio is interested in aerodynamic interactions arising in both internal and external flows and extending over a wide range of Reynolds numbers. The portfolio seeks to advance fundamental understanding of complex, time-dependent flow interactions by integrating theoretical/analytical, numerical, and experimental approaches. The focus on the understanding of the fundamental flow physics is motivated by an interest in developing physically-based predictive models and innovative control concepts for these flows. Research in this portfolio is motivated, in part, by the unique fluid-structure interactions that are found in nature, in vortex and shear layer flows, and on small-scale, unmanned air vehicles.

Basic Research Objectives: The portfolio emphasizes the characterization, modeling/prediction, and control of flow instabilities, turbulent fluid motions, and fluid-structure interactions for both bounded and free-shear flows with application to aero-optics, surfaces in actuated motion, flexible and compliant aerodynamic surfaces, vortical flows, and

flows with novel geometric configurations. The portfolio maintains an interest in the dynamic interaction between unsteady fluid motion, nonlinear structural deformations, and aerodynamic control effectors for a wide range of flight regimes. Although the portfolio places a strong emphasis on flow control, studies examining fundamental flow physics with a path to enabling control of the flow are also of interest. Studies integrating modeling, control theory, and advanced sensor and/or actuator technology for application to a flow of interest are encouraged. Flow control studies are expected to involve a feedback approach based on a fundamental insight into the flow dynamics.

Basic research of the variety typically funded by the portfolio may not yet have a clear transition path to an application. The integration of theoretical, numerical, and experimental tools to improve understanding is encouraged.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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4. Multi-Scale Structural Mechanics and Prognosis

Program Description: This fundamental basic research program addresses the U.S. Air Force needs in the following application areas: 1) New and revolutionary flight structures, 2) Multi-scale modeling and prognosis and 3) Structural dynamics under non-stationary conditions and extreme environments. Other game-changing and revolutionary structural mechanics problems relevant to the U.S. 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. The program seeks to establish the fundamental understanding required to design and manufacture new aerospace materials and structures and to predict their performance and integrity based on mechanics principles.

Basic Research Objectives: Fundamental basic research issues for new and revolutionary flight structures include: revolutionary structural concepts and unprecedented flight configurations; hybrid structures of dissimilar materials (metallic, composite, ceramic, etc.) with multi-material joints and/or interfaces under dynamic loads, and extreme environments; controlled-flexibility distributed-actuation smart structures. The predictive analysis and durability prognosis of hybrid-material structures that synergistically combine the best attributes of metals, composites, and ceramics, while avoiding their inherent shortcomings are of great interest.

Fundamental basic research issues of interest for multi-scale modeling and prognosis include: physics-based models that quantitatively predict the materials performance and durability of metallic and composite flight structures operating at various regimes; modeling and 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; novel and revolutionary on-board health monitoring and embedded NDE concepts.

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; 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 contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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5. Optimization and Discrete Mathematics

Program Description: 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 U.S. 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 performance, operational efficiency, and optimal control of dynamical systems, and in artificial intelligence and information technology applications.

Basic Research Objectives: 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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6. Test and Evaluation (T&E)

Program Description: The T&E program supports basic research which will build the foundation for future revolutionary capabilities that address the identified needs of the T&E Community. As new technologies emerge, the ability to test new capabilities as they are assimilated into applied R&D is a critical part of the development process. The T&E Program sponsors basic research in areas that enable such testing and areas that allow the correct and comprehensive interpretation of test results. Fast and effective Test Science and Test Engineering lead to: improved ability to identify problems, understand causes, and recommend solutions; reduced product development time; improved quality; improved performance; better acquisition program decisions; increased acquisition program flexibility; meeting schedule deadlines; reduce test-and-fix cycle costs; reaching or exceeding performance goals; and superior products. The current T&E Program encompasses five broadly-defined, overlapping thrust areas: Hypersonics, Aeroelasticity and Aerodynamics, Sensors and Electromagnetics, Information and Data Management and Fusion, and Enabling Materials. The Program is closely aligned with many other AFOSR program interests, but with special emphasis on aspects of basic research that lead to revolutionary advances in areas such as metrology and test science.

Basic Research Objectives: The T&E Program is closely engaged with technical experts at Air Force Developmental Test and Evaluation organizations located at Edwards, Arnold, and Eglin Air Force Bases, who help advise the program on basic research objectives. Basic research in areas that advance the science of testing is broadly defined and spans mathematics as well as most disciplines in engineering and the physical sciences. Areas include:

- Novel measurement techniques, materials, and instruments that enable accurate, rapid, and reliable test data collection of physical, chemical, mechanical, and flow parameters in extreme environments, such as those encountered during transonic flight, hypersonic flight, and the terminal portion of weapons engagement
- Accurate, fast, robust, integratable models of the aforementioned that reduce requirements to test or help provide greater understanding of test results
- Advanced algorithms and computational techniques that are applicable to new generations of computers, including massively parallel, quantum, and neuromorphic machines
- Advanced algorithms and test techniques that allow rapid and accurate assessment of devices and software to cyber vulnerability
- New processes and devices that increase bandwidth utilization and allow rapid, secure transfer of test data to control facilities during test, with special emphasis on telemetry
- Advanced mathematical techniques that improve design of experiment or facilitate confident comparison of similar but disparate tests
- Advanced models of test equipment and processes that improve test reliability and efficiency
- New or advanced technologies that enable the test process
- Basic research in other T&E technical areas that advances the science of test and contributes to the development of knowledge, skills, and abilities of the established or emerging AF T&E workforce.

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7. Turbulence and Transition

Program Description: The objective of the Turbulence and Transition portfolio is to develop the fundamental fluid physics knowledge base required for revolutionary advancements in a broad variety of future U.S. Air Force capabilities including aerodynamically-efficient aerospace systems, rapid global and regional response, and thermal/environmental management. Research supported by this portfolio seeks to characterize, model and exploit/control critical fluid dynamic phenomena through a balanced mixture of investments in experimental, numerical and theoretical efforts.

Basic Research Objectives: Innovative research is sought in all aspects of turbulent and transitional flows with particular interest in efforts that explore the dynamics and mechanisms of energy transfer within high-speed viscous flows. Topics of interest include, but are not limited to, the following:

- Laminar-turbulent stability, receptivity, transition and turbulence in high-Mach number boundary layers, especially approaches leading to greater insight into surface heat transfer.
- Characterization and modeling of the impact of realistic surface conditions on transitional and turbulent flows in all speed regimes.
- Innovative experiments and numerical simulations that identify the underlying physics and potential control mechanisms for noise radiated from high-speed hot jets.

The behavior of viscous flows impacts the performance of all aerodynamic, propulsion, and environmental management systems and frequently determines the environment experienced by the system structure. The development of accurate methods for predicting the behavior of transitional and turbulent flows across a wide range of flow conditions will facilitate the design of future systems with optimized performance and energy-efficiency. Research areas of interest emphasize the characterization, prediction and control of high-speed fluid dynamic phenomena which will provide the scientific foundation for game-changing advancements in aerodynamics, environmental (thermal and acoustic) management, propulsion, and directed energy.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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b. Quantum and Non-Equilibrium Processes (RTB):

The Quantum and Non-Equilibrium Processes Department leads the discovery and transition of foundational physical science to enable air, space, and cyber power. Research in physics generates the fundamental knowledge needed to advance U.S. Air Force operations, from the perspective of sensing, characterizing, and managing the operational environment as well as developing advanced devices that exploit novel physical principles to bring new capabilities to the warfighter. Research directions are categorized in three broad areas, and the focus is on advancing our basic understanding of the physical world:

Fundamental Quantum Processes: This includes exploration and understanding of a wide range of atomic, molecular, and optical phenomena, including strongly coupled electronic phenomena that occurs in complex materials in all physical phases, including but not limited to non-linear optical materials, Metamaterials, cathodes, dielectric and magnetic materials, high energy lasers, semiconductor lasers, and ultra-fast lasers. Additionally, RTB looks to fund research into new classes of quantum phenomena that both creates new knowledge of the physical world and improve the state-of-the-art for devices that perform sensing, information processing, and novel concepts for quantum computing. This area also includes generating and controlling quantum states, such as superposition and entanglement, in photons, ultracold atoms and molecules, and ultracold plasmas. In addition to research into underlying materials and fundamental physical processes, this area considers how they might be integrated into new classes of devices, seeking breakthroughs in quantum information processing and memory, secure and high speed communication, and fundamental understanding and simulation of materials that are not amenable to conventional computational means (e.g., using cold atoms and optical lattices to model high-temperature superconductors).

Plasma Physics and High Energy Density Nonequilibrium Processes: This area includes a wide range of activities characterized by processes that are sufficiently energetic to require the understanding and managing of plasma phenomenology including the non-linear response of materials to large electric and magnetic fields. For example space weather, plasma control of boundary layers in turbulent flow, plasma discharges, RF propagation and RF-plasma interaction, and high power beam-driven microwave devices are areas of great interest. Also, topics where plasma phenomenology is not necessarily central to the activity but is nonetheless an important aspect, such as laser-matter interaction (including high energy as well as ultrashort pulse lasers) and pulsed power are prime areas of research interest. This area pursues advances in the understanding of fundamental plasma and non-linear electromagnetic phenomenology, including modeling and simulation, as well a wide range of novel potential applications involving matter at high energy density.

Optics and Electromagnetics: This area considers all aspects of producing, modifying, and receiving complex electromagnetic and electro optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. It also covers aspects of the phenomenology of lasers and non-linear optics and the interaction of electromagnetic signals with circuitry. This area not only considers the advancement of physical devices to enable the activities mentioned above and provide robust operation in the face of interference, and includes

sophisticated mathematics and algorithmic development for extracting information from complex and or sparse signals as a central theme. This cross-cutting activity impacts such diverse efforts as space object imaging, secure reliable communication, novel electronic warfare schemes, non-destructive test and evaluation, and propagation of directed energy.

The quantum and non-equilibrium physics programs include theoretical and experimental physics from all disciplines, including biology and engineering. Issues such as those found in microwave or photonic systems as well as materials-processing techniques are of interest. A main objective of the program is to balance innovative science and U.S. Air Force relevance, being forward looking to anticipate future U.S. Air Force needs while understanding the current state-of-the-art in the physical sciences.

The RTB research portfolios and their program officers are listed here:

- 1) Biophysics, Dr. William P. Roach
- 2) Atomic and Molecular Physics, Dr. Tatjana Curcic
- 3) Electromagnetics, Dr. Arje Nachman
- 4) Laser and Optical Physics, Dr. Howard R. Schlossberg
- 5) Plasma and Electro-Energetic Physics, Dr. John W. Luginsland and Dr. Jason A. Marshall
- 6) Remote Sensing and Imaging Physics, Dr. Julie Moses
- 7) Space Science, Dr. Kent Miller
- 8) Ultrashort Pulse Laser-Matter Interactions, Dr. Enrique Parra

Research of interest to these sub areas is described in detail below:

1. Biophysics

Program Description: This program encompasses fundamental experimental and theoretical Biophysics research that is primarily focused on studies of bio-molecular and atomic imaging below the diffraction limit, bioelectricity, electromagnetic stimulation, and quantum biology. We are concerned then, with the study of physical biology with the aim of answering fundamental and basic physics questions through the application of the principles and methods of physical sciences to achieve novel and innovative solutions in biology and physics. The relatively recent emergence of biophysics as a scientific discipline may be attributed to the spectacular success of biophysical tools born out of a physics understanding that have allowed us to unravel the complex molecular structures found in DNA and RNA. More recently areas of interest in Biophysics include, but are not limited to bio-molecular imaging below the diffraction limit, bioelectricity, electromagnetic stimulation and quantum biology. These research areas support technological advances in application areas of interest to the United States Air Force including biologically inspired new innovative and novel materials, human performance, and enhanced computational development for future Air Force needs.

Basic Research Objectives: We are initiating a new, multidiscipline collaborative basic research effort that meets scientifically meritorious rigor in the area of Biophysics. We seek to directly or indirectly support the efforts of the Air Force Research Laboratories ongoing in house research in Biophysics and Human Performance. We seek to explore new areas in applied

mathematics, physics, and biology by working in the sub-areas of bio-molecular imaging below the diffraction limit, bioelectricity, electromagnetic stimulation, quantum biology and mechanisms of sensory systems.

As examples, nano-pores have been shown to form in the plasma membranes of mammalian cells upon exposure to nanosecond pulsed electric fields with complete functional recovery. High-speed imaging is now a reality yet its goal of working below the diffraction limit to allow for a more rapid signaling acquisition process while illuminating the mechanisms of action from the cellular membrane to the interior structures of the cell has yet to be realized. Bioelectronics, no longer limited to solid-state device faux-integration with biological systems, can now create bio-analog circuitry. Recent work has found that rapid change in temperature from the IR laser stimulation reversibly alters the electrical capacitance of the plasma membranes of a cell and depolarization of the membrane can result in real measurable action potentials. This capacitance is established by the spatial distributions of ions near the plasma membrane surface and underlies the mechanism responsible for the voltage waves in the Soliton theory of action potentials. Finally, this program coordinates multi-disciplinary experimental research with mathematical, neuromorphic, and computational modeling to develop the basic scientific foundation to understand and emulate sensory information systems in natural acoustic, visual, and sensorimotor systems.

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2. Atomic and Molecular Physics

Program Description: This program encompasses fundamental experimental and theoretical Atomic and Molecular physics research that is primarily focused on studies of cold and ultra-cold quantum gases, precision measurement, and quantum information science (QIS) with atoms, molecules, and light. These research areas support technological advances in application areas of interest to the U.S. Air Force, including precision navigation, timekeeping, remote sensing, secure communication, metrology, and novel materials for the U.S. Air Force needs in the future.

Basic Research Objectives: AMO (Atomic, Molecular and Optical) 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 quantum phases of matter; non-equilibrium dynamics of cold quantum gases; cold/ultracold plasmas; ultracold chemistry; precision spectroscopy; novel clocks; and high-precision techniques for navigation, guidance, and remote sensing.

QIS 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; quantum optomechanics; application of controlled coherent interactions to direct the dynamics of quantum systems; and novel approaches to quantum information processing.

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3. Electromagnetics

Program Description: This portfolio supports research in Electromagnetics (EM) whose objective is the interrogation (modeling/simulation) of linear/nonlinear Maxwell's equations.

Basic Research Objectives: Basic research to produce conceptual descriptions of electromagnetic properties of novel materials/composites (such as photonic band gap media, negative index media, Parity-Time symmetry media, etc.) and the simulation of their uses in various operational settings is encouraged. Basic research in inverse scattering theory in order to promulgate new methods which recognize and track targets or upgrade efforts to pursue Nondestructive Evaluation is encouraged. Efforts to identify suitable wideband radar waveforms to penetrate foliage, clouds, buildings, the ionosphere, or other dispersive/random/turbulent media as well as to design transmitters to produce such waveforms are also supported. Research which develops the mathematical underpinning for computational electromagnetic simulation codes (both frequency domain and time domain) that are rapid and whose claims of accuracy are accompanied by rigorous error estimates/controls is encouraged. In the area of nonlinear Maxwell's equations, commonly called nonlinear optics, research pursues descriptions of nonlinear EM phenomena such as the propagation of Ultrashort laser pulses through air, clouds, etc and any possible exploitation of these pulses is supported. Such mathematical descriptions are anticipated to be a coupled system of nonlinear partial differential equations. Basic research in other nonlinear EM phenomena include the dynamics of the EM field within solid state laser cavities (particularly the modeling/simulation of nonequilibrium carrier dynamics within semiconductor lasers) and fiber lasers, the propagation of light through various nonlinear crystals (including Graphene), as well as other nonlinear optical media. All such modeling/simulation research is complementary to the experimental portfolios within AFOSR. Another area of interest is the description and understanding of any chaos in circuitry which can possibly be created by exposure to suitable EM fields.

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4. Laser and Optical Physics

Program Description: The program goal is to advance the science of laser devices and systems, nonlinear optical phenomena and devices, and unique applications of these to solving scientific and technological problems. Novel light sources are also an objective of this program, particularly in regions of the spectrum not otherwise easily available or with characteristics able to again address important scientific and technological issues.

Basic Research Objectives: This U.S. Air Force program seeks innovative approaches and novel concepts that could lead to transformational advances in high average power lasers for future applications related to directed-energy. Examples of such areas include novel processing techniques for high quality ceramic laser materials with control over spatial distributions of dopants and index of refraction, and processing methods for achieving low loss laser ceramics with non-isotropic, including those with aligned, grains. Aligned grain ceramic materials are also of interest as large size, high average power nonlinear optical materials using quasi-phases matching techniques. Recrystallization of large, low loss ceramic laser materials is of high interest. New ideas for high average power fiber lasers are of interest, including new materials, and large mode area structures, novel ways of mitigating nonlinear issues, and studies of coupling multiple fiber lasers which can withstand very high average power. Novel, compact, particularly tunable or wavelength flexible, potentially inexpensive, infrared lasers are of interest for infrared countermeasures or for gas sensing applications. Relatively small novel sources of monochromatic x-rays are also of interest as are innovative imaging with such sources. More broadly, the Laser and Optical Physics program is interested and will consider any novel and potentially transformational ideas, and is especially interested in inter-disciplinary research, within the broad confines of its title.

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5. Plasma and Electro-Energetic Physics

Program Description: The objective of this program is to understand and control the interaction of electromagnetic energy and charged particles to produce useful work in a variety of arenas, including directed energy weapons, sensors and radar, electronic warfare, communications, novel compact accelerators, and innovative applications of plasma chemistry, such as plasma-enhanced combustion and plasma aerodynamics. While the focus of this effort is the generation and collective interaction of electromagnetic fields and plasmas, advances in the enabling technology of compact pulsed power, including innovative dielectric and magnetic materials for high-density energy storage, switching devices, and non-linear transmission lines are also of fundamental interest. This portfolio will also consider research increasing the scientific understanding required to predict heat transfer across a broad range of temporal and spatial scales, both in plasmas, in the connection of plasma to energy supplying electrodes, and in advanced materials facing the extreme environments associated with energy dense materials.

Basic Research Objectives: Ideas for advancing the state-of-the-art in the following areas are strongly encouraged: highly efficient electron-beam-driven sources of high-frequency microwave, millimeter-wave, and sub-millimeter coherent radiation (high power microwaves [HPM] and/or vacuum electronics), high-power amplifiers, novel dispersion engineering via metamaterials and photonic band gap structures, novel sources of relativistic particle beams, laser plasma/matter interaction, compact pulsed power, particle-field interaction physics, power-efficient methods to generate and maintain significant free-electron densities in ambient air, plasma chemistry at high pressure, and the physics of strongly coupled plasmas. New concepts for the theory, modeling, and simulation of these physical phenomena are also of interest, including combined experimental/theoretical/simulation efforts that verify and validate innovative models. Proposals addressing fundamental science are sought in the areas of phonon transport, contribution of phonon dispersion modes to thermal transport, understanding of extreme thermal conductivity, and thermal conductivity in hybrid materials, including the role of radiative processes. Proposals addressing new ideas and directions related to understanding of thermal transport and phonon-assisted devices are highly encouraged, especially as they relate to operation in hostile environments consistent with high energy density physics. Researchers should also consult the program in Aerospace Materials for Extreme Environments as described in this Broad Agency Announcement to find the best match for research concerning thermal physics.

Ideas relating to plasmas and electro-energetic physics in space are of interest to this program, but researchers should also consult the programs in Space Power and Propulsion and in Space Sciences as described in this Broad Agency Announcement to find the best match for the research in question. Additionally, laser plasma/matter interaction, while of interest to this portfolio, is generally limited to the non-equilibrium physics of plasmas; other concepts related to laser-matter interactions should consult the Ultrashort Pulse Laser-Matter Interactions or Laser and Optical Physics programs as described in this Broad Agency Announcement. Innovative science that combines plasma and electro-energetic physics with the high-energy density associated with nuclear forces (e.g. nuclear batteries where radiation produces currents in semiconductors and propulsion plasmas sustained via fusion) will be considered. Nuclear fission or fusion for large-scale energy production is not of prime interest to this portfolio.

Researchers are highly encouraged to contact both of the Program Officers prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort. Collaborative effort with the researchers at the Air Force Research Laboratory is encouraged, but not required.

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6. Remote Sensing and Imaging Physics

Program Description: This program investigates fundamental issues concerning remote sensing and the physics of imaging, including image formation processes, non-imaging sensing, propagation of electromagnetic radiation, the interaction of radiation with matter, remote target detection and identification, the effect of the atmosphere or space environment on imaging systems and sensors, and the detection and tracking of resident space objects. Proposals are sought in all areas of ground, air, and space-based remote sensing and imaging, but particularly in the detection, characterization, and identification of space objects. This program includes the investigation of fundamental processes that affect space situational awareness. Technological advances are driving the requirement for innovative methods to detect, identify, and predict trajectories of smaller and/or more distant objects in space. New optical capabilities that complement traditional radar tracking of satellites, as well as increased resolution and sensitivity, are leading to the need for faster and more accurate methods of characterization.

Basic Research Objectives: Research goals include, but are not limited to:

- Theoretical foundations of remote sensing and imaging.
- 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.
- Propagation of coherent and incoherent electromagnetic radiation through a turbulent atmosphere. (Theoretical and mathematical aspects of this area should also see the BAA input for Electromagnetics - AFOSR Program Officer is Dr. Arje Nachman.)
- Innovative methods of remote target location, characterization, and tracking, as well as non-imaging methods of target identification.
- Understanding and predicting dynamics of space objects as it relates to space object identification and space situational awareness.
- 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 and/or emission from objects in space and the instrumentation requirements for next generation space surveillance systems.
- Remote sensing signatures and backgrounds of both ground-based and space-based observations.
- The interaction of U.S. Air Force imaging systems and sensors with the space environment. This includes the understanding of conditions that affect target identification, such as environmental changes and surface aging or weathering.

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7. Space Science

Program Description: The AFOSR Space Science program supports basic research on the solar-terrestrial environment extending from the Sun through Earth's magnetosphere and radiation belts to the mesosphere and lower thermosphere region. This geospace system is subject to solar radiation, particles, and eruptive events, variable interplanetary magnetic fields, and cosmic rays. Perturbations to the system can disrupt the detection and tracking of aircraft, missiles, satellites, and other targets; distort communications and navigation signals; interfere with global command, control, and surveillance operations; and negatively impact the performance and longevity of U.S. Air Force space assets.

A long-term goal for the program is development of a physics-based predictive coupled solar-terrestrial model that connects solar activity and emissions with resultant effects on Earth's radiation belts, magnetosphere, ionosphere, and neutral atmosphere. To achieve this, fundamental research focused on improving understanding of the physical processes in the geospace environment is encouraged. Particular goals are to improve operational forecasting and specification of solar activity, thermospheric neutral densities, and ionospheric irregularities and scintillations. Activities that support these goals may include validating, enhancing, or extending solar, ionospheric, or thermospheric models; investigating or applying data assimilation techniques; and developing or extending statistical or empirical models. An important aspect of the physics is understanding and represents the coupling between regions, such as between the solar corona and solar wind, between the magnetosphere and ionosphere, between the lower atmosphere and the thermosphere/ionosphere, and between the equatorial, middle latitude, and Polar Regions.

Basic Research Objectives: Research goals include, but are not limited to:

- The structure and dynamics of the solar interior and its role 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;
- The triggering and temporal evolution of geomagnetic storms;
- The variations in solar radiation received at Earth and its effects on satellite drag;
- The impacts of geomagnetic disturbances on the thermosphere and ionosphere;
- Electron density structures and ionospheric scintillations;
- Ionospheric plasma turbulence and dynamics;
- The effects of neutral winds, atmospheric tides, and planetary and gravity waves on the neutral atmosphere densities and on the ionosphere.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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8. Ultrashort Pulse Laser-Matter Interactions

Program Description: The Ultrashort Pulse Laser-Matter Interactions program is focused on the most fundamental process in nature, the interaction of light with the basic constituents of matter. The objective of the program is to explore and understand the broad range of physical phenomena accessible via the interaction of ultrashort pulse (USP) laser sources with matter in order to further capabilities of interest to the U.S. Air Force, including directed energy, remote sensing, communications, diagnostics, and materials processing. The portfolio explores research opportunities accessible by means of the three key distinctive features of USP laser pulses: high peak power, large spectral bandwidth and ultrashort temporal duration.

Basic Research Objectives: The Ultrashort Pulse Laser-Matter Interactions program seeks innovative science concepts in the research focus areas of high-field laser physics, frequency combs and attosecond science described below:

- **High-field laser physics:** Over the last two decades, progress in laser pulse amplification techniques has resulted in a six order of magnitude increase in achieved focused intensities. The interaction of such intense radiation with matter results in rapid electron ionization and a rich assortment of subsequent interaction physics. Topics of interest in this area include, but are not limited to, techniques for ultrafast- laser processing (e.g. machining, patterning), mechanisms to control dynamics of femtosecond laser propagation in transparent media (e.g. filamentation), concepts for monochromatic, tunable laser-based sources of secondary photons (e.g. extreme ultraviolet, terahertz, x-rays) and particle beams (e.g. electrons, protons, neutrons), laser-based compact particle accelerators and concepts for high peak power laser architectures and technology that efficiently scale up to high repetition rates and/or new wavelengths of operation.
- **Optical frequency combs:** The large coherent spectral bandwidths intrinsic to USP lasers make them especially suitable for applications requiring high temporal and spectral precision such as telecommunications, optical clocks, time and frequency transfer, precision spectroscopy and arbitrary waveform generation. Research topics in this thrust area include, but are not limited to, dispersion management techniques to increase the spectral coverage to exceed an octave while maintaining high powers per comb, new concepts to extend frequency combs from the extreme ultraviolet into the mid-wave and long-wave infrared spectral regimes, development of novel resonator designs (e.g. micro-resonator based) and ultra-broadband pulse shaping.
- **Attosecond science:** The development of intense light pulses with attosecond durations has resulted in stroboscopic probes with the unprecedented ability to observe atomic-scale electron dynamics with attosecond temporal resolution. This highly exploratory thrust of the

program is interested in developing research aimed at resolving attosecond electron dynamics in complex systems of interest to DOD (i.e. such as solid-state semiconductor, magnetic, and plasmonic systems). If successful, such understanding would have a broad and direct impact on future materials research, moving us closer to designing materials with carefully engineered electronic properties. Topics of interest in this area include, but are not limited to, new concepts for improved attosecond sources (e.g. increased efficiency, higher flux, shorter pulses, and higher photon energy), development of pump-probe methods that investigate interactions with systems ranging from isolated atoms / molecules to condensed matter, attosecond pulse propagation, novel concepts for attosecond experiments and fundamental interpretations of attosecond measurements.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

Research efforts requesting consideration for FY14 funds should plan to have proposals submitted by May 30, 2014.

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c. Information, Decision and Complex Networks (RTC):

The Information, Decision, and Complex Networks Department is designed to support many U.S. Air Force priority areas including space situational awareness, autonomy, and cyber. The programs in the Department include Complex Networks, Computational and Machine Intelligence, Dynamic Data Driven Application Systems, Foundations of Information Systems, Information Operations and Security, Mathematical and Computational Cognition, Science of Information Computation and Fusion, Sensing Surveillance and Navigation, Systems and Software, and Trust and Influence.

Information: Critical challenges for the U.S. Air Force moving forward lie at the intersection of the ability to collect, mathematically analyze, and disseminate large quantities of information in a time critical fashion with assurances of operation and security from the infrastructure to the mission levels of the systems. The Science of Information, Computation and Fusion Program enables the ability to collect, disseminate and integrate information in such a way as to mathematically characterize and assess the most appropriate information for a range of mission critical tasks. The Sensing Surveillance and Navigation Program develops algorithms to collect and decompose critical sensing information and enables techniques that interface between the physical domains such as Electromagnetics and methods in navigation and geo-location. The Dynamic Data Driven Applications Program enables analysis of the interplay between physical systems such as fluid dynamical systems and software systems and architectures as in the case of aircraft flight systems. The Information Operations and Security Program looks at fundamental issues for assessing systems in terms of secure operations and mission performance

and the Systems and Software Program assesses these systems from a verification and validation standpoint to guarantee operations under a variety resource constraints.

Decision Making: This thrust focuses on the discovery of mathematical laws, foundational scientific principles, and new, reliable and robust algorithms, which underlie intelligent, mixed human-machine decision-making to achieve accurate real-time projection of expertise and knowledge into and out of the battle space. The Computational and Machine Intelligence as well as the Mathematical and Computational Cognition Programs focus on machine and human cognition and learning. The objective is to maximize the ability of machines to conduct higher level cognitive activities with quantifiable risk and accurate models of human decision makers. The Trust and Influence Program seeks to model and measure the way a collection of individuals make decisions and are influenced both in small groups and culturally.

Complex Networks: Complex Networks consists of the Complex Networks Program and the Foundations of Information Systems Program. Complex Networks is designed to mathematically represent networks of all kinds including communications and computation at all levels including content, protocol, and architecture. This mathematically unified representation is meant to measure, represent, resource, and secure critical infrastructures for U.S. Air Force and Department of Defense (DoD) applications. Additionally, the Foundations of Information Program is designed to use measurements and representations from the Complex Networks Program to verify and validate critical infrastructure performance.

The RTC research portfolios and their program officers are listed here:

- 1) Complex Networks, Dr. Robert Bonneau
- 2) Computational and Machine Intelligence, Dr. James Lawton
- 3) Dynamic Data Driven Applications Systems (DDDAS), Dr. Frederica Darema
- 4) Foundations of Information Systems, Dr. Robert Bonneau
- 5) Information Operations and Security, Dr. Robert L. Herklotz
- 6) Mathematical and Computational Cognition, Dr. James Lawton
- 7) Robust Decision Making in Human-System Interface, Dr. James Lawton
- 8) Science of Information, Computation and Fusion, Dr. Tristan Nguyen
- 9) Sensing, Surveillance and Navigation, Dr. Tristan Nguyen
- 10) Systems and Software, Dr. Kathleen Kaplan
- 11) Trust and Influence, Dr. Benjamin Knott

Research areas are described in detail in the Sub areas below:

1. Complex Networks

Program Description: Network behavior is influenced at many levels by fundamental theories of information exchange in the network protocols and policies developed. The Complex Networks program seeks to understand mathematically how such fundamental approaches to information exchange influence overall network performance and behavior. From this analysis we wish to develop strategies to assess and influence the predictability and performance of heterogeneous types of U.S. Air Force networks that must provide reliable transfer of data in

dynamic, hostile and high interference environments. Accordingly, we wish to develop approaches to describe information content, protocol, policy, structure, and dynamic behavior of a network by mathematically connecting observed network data to analytic and geometric representation. We can then exploit such mathematical tools in the formulation of network design and engineering approaches in areas such as information and communication theory, signal processing, optimization, and control theory. Examples of such tools might include methods derived from algebraic geometry, algebraic statistics, spectral graph theory, sparse approximation theory, random matrix theory, algebraic graph theory, random field theory, nonparametric estimation theory, algebraic topology, differential geometry, and dynamical systems theory, and quantum information theory. Advances in these mathematical methods will then enable specific ways to model, characterize, design, and manage U.S. Air Force networks and capture and predict the performance of these networks under many diverse conditions.

Basic Research Objectives: 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 methods classify network behavior and structure through multi-scale vector space and 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 protocol and policy for various network dynamical conditions with such properties as curvature, homology class, or geometric flow. Approaches should have specific applicability to U.S. Air Force networking, communications, and architectural design problems but may be drawn from techniques in network analysis from a broad set of disciplines including quantum information systems, materials science and statistical mechanics, molecular and systems biology, wave propagation physics, decision, economics, and game theory to name just a few. From this we can conceive of new directions toward a science of networked systems.

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2. Computational and Machine Intelligence

Program Description: This program supports basic research in computational intelligence. This program supports innovative basic research on fundamental principles and methodologies of computational intelligence necessary to create robust intelligent autonomous systems. Robustness is defined as the ability to achieve high performance given at least some or all of the following factors: uncertainty, incompleteness or errors in knowledge; limitations on sensing; real-world complexity and dynamic change; adversarial factors; unexpected events including

system faults; and out-of-scope requirements on system behavior. The vision of this program is that future computational intelligence systems will achieve high performance, adaptation, flexibility, self-repair, and other forms of intelligent behavior in the complex, uncertain, adversarial, and highly dynamic environments faced by the U.S. Air Force.

Basic Research Objectives: The program encourages research on building computational intelligence systems that derive from and/or integrate cognitive and biological models of human and animal intelligence. The investigative methodology may be theoretical, computational, or experimental, or a combination of thereof. Proposals to advances in the basic principles of machine intelligence for memory, reasoning, learning, action, and communication are desired insofar as these contribute directly towards robustness as defined above. Research proposals on computational reasoning methodologies of any type and combination, including algorithmic, heuristic, or evolutionary, are encouraged as long as the proof of success is the ability to act autonomously or in concert with human teammates to achieve robustness as defined above. Computational intelligence systems often act as human intelligence amplifiers in such areas as planning, sensing, situation assessment and projection; will monitor, diagnose, and control aircraft or spacecraft; and will directly interact with humans and the physical world through robotic devices. Therefore, research that that enables mixed-initiative interaction and teaming between autonomous systems and human individuals or teams is an important part of the program. Basic research that bridges the conceptual gaps between state-of-the-art statistical/machine learning algorithms and human cognition and performance are also welcomed. The program encourages multidisciplinary research teams, international collaborations, and multi-agency partnerships. This program is aggressive, accepts risk, and seeks to be a pathfinder for U.S. Air Force research in this area. Proposals that may lead to breakthroughs or highly disruptive results are especially encouraged.

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3. Dynamic Data Driven Applications Systems (DDDAS)

Program Description: The DDDAS concept entails the ability to dynamically incorporate additional data into an executing application, and in reverse, the ability of an application to dynamically steer the measurement (instrumentation and control) components of the application system. DDDAS is a key concept for improving modeling of systems under dynamic conditions, more effective management of instrumentation systems, and is a key concept in architecting and controlling dynamic and heterogeneous resources, including, sensor networks, networks of embedded controllers, and other networked resources. DDDAS transformative advances in computational modeling of applications and in instrumentation and control systems (and in particular those that represent dynamic systems) require multidisciplinary research, and specifically need synergistic and systematic collaborations between applications domain researchers with researchers in mathematics and statistics, researchers computer sciences, and researchers involved in the design/ implementation of measurement and control systems (instruments, and instrumentation methods, and other sensors and embedded controllers).

Basic Research Objectives: Individual and multidisciplinary research, technology development, and cyberInfrastructure software frameworks needed for DDDAS applications and their environments are sought, along four key science and technology frontiers: Applications modeling: In DDDAS an application/simulation must be able to accept data at execution time and be dynamically steered by such dynamic data inputs. This requires research advances in application models that: describe the application system at different levels of detail and modalities; are able to dynamically invoke appropriate models as needed by the dynamically injected data into the application; and include interfaces of applications to measurements and other data systems. DDDAS will, for example, engender an integration of large scale simulation with traditional controls systems methods, thus provide an impetus of new directions to traditional controls methods. Advances in Mathematical and Statistical Algorithms include creating algorithms with stable and robust convergence properties under perturbations induced by dynamic data inputs: algorithmic stability under dynamic data injection/streaming; algorithmic tolerance to data perturbations; multiple scales and model reduction; enhanced asynchronous algorithms with stable convergence properties; multimodal, multiscale modeling and uncertainty quantification, and in cases where the multiple scales or modalities are invoked dynamically and there is need for fast methods of uncertainty quantification and uncertainty propagation across dynamically invoked models. Such aspects push to new levels of challenges the traditional computational math approaches. Application Measurement Systems and Methods include improvements and innovations in instrumentation platforms, and improvements in the means and methods for collecting data, focusing in a region of relevant measurements, controlling sampling rates, multiplexing, multisource information fusion, and determining the architecture of heterogeneous and distributed sensor networks and/or networks of embedded controllers. The advances here will create new instrumentation and control capabilities. Advances in Systems Software runtime support and infrastructures to support the execution of applications whose computational systems resource requirements are dynamically dependent on dynamic data inputs, and include: dynamic selection at runtime of application components embodying algorithms suitable for the kinds of solution approaches depending on the streamed data, and depending on the underlying resources, dynamic workflow driven systems, coupling domain specific workflow for interoperation with computational software, general execution workflow, software engineering techniques. The systems software environments required are those that can support execution in dynamically integrated platforms ranging from the high-end to the real-time data acquisition and control - cross-systems integrated. Software Infrastructures and other systems software (OS, data-management systems and other middleware) services to address the “real time” coupling of data and computations across a wide area heterogeneous dynamic resources and associated adaptations while ensuring application correctness and consistency, and satisfying time and policy constraints. Specific features include the ability to process large volume, high rate data from different sources including sensor systems, archives, other computations, instruments, etc.; interfaces to physical devices (including sensor systems and actuators), and dynamic data management requirements.

Areas of interest to the AF and which can benefit from DDDAS transformative advances, include areas driven by the AF Technology Horizons, Energy Horizons, and Global Horizons reports, such as: autonomous systems (e.g. swarms of unmanned or remotely piloted vehicles); autonomous mission planning; complex adaptive systems with resilient autonomy;

collaborative/cooperative control; autonomous reasoning and learning; sensor-based processing; ad-hoc, agile networks; multi-scale simulation technologies and coupled multi-physics simulations; decision support systems with the accuracy of full scale models (e.g. high-performance aircraft health monitoring, materials stresses and degradation); embedded diagnostics and V&V for complex adaptive systems; automated software generation; cognitive modeling; cognitive performance augmentation; human-machine interfaces. DDDAS provides new approaches for combining computational, theoretical, and instrumentation data sets for high interactive testing of multiple physical and engineering hypotheses.

Programmatic activities that will be launched under this initiative will support research in individual areas, but mostly in the context of multidisciplinary research across at least two of the four components under Basic Area Objectives above.

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4. Foundations of Information Systems

Program Description: The Foundations of Information Systems program intends to foster fundamental research on new methods for analysis, management, and design of complex information systems. Traditional approaches to systems methods involve verification or equivalence model checking paradigms for software and hardware components, and are limited to analysis of individual-components in the design cycle. We seek to enable comprehensive system-level analysis, optimized performance, function, behavior, operation, fault-tolerance, robustness, adaptability and cyber-security among other properties. These approaches should be considered throughout the design, operation, and expansion of the system. Foundations of Information Systems seek to characterize the analysis of systems in multi-scale representations of sub-components and system-layers, derived from specifications, models and measurements. Because of the heterogeneous and dynamic nature of information systems, increasing emphasis on measurement-based performance analysis is necessary to develop the capabilities sought here. Therefore, we seek methods that allow integration between specifications-based methods and measurement-based methods which involve statistical analysis and dynamical systems theory to estimate the current true state and performance of the system as a whole. Such new methods should enable quantifiable, performance-driven systems-engineering and more powerful analysis capabilities for managing the design, operation, and scalability of systems that need to be adaptive and interoperable.

Basic Research Objectives: Fundamental strategies that integrate specification or model based methods with measurement based, statistics, risk, and dynamical system methods into a unified framework are thus of great interest. Of particular interest are multidisciplinary research efforts creating new approaches and methods that bridge across analytic, agent-based, graph-based, event-driven, and statistical Bayesian approaches, with techniques utilizing methods from model equivalency checking. Techniques in verification drawn from probabilistic process algebras, model checking, categorical logic theory, and algebraic representation theory are of interest as

are methods in sparse approximation, parametric and nonparametric estimation, functional analysis, and geometric inference for system measurement and identification. Also of interest are entropy-based systems metrics, mean-field-theory, information-flow analysis and nonlinear optimization for risk assessment; operator and sheaf theoretic methods, computational homology, rigidity theory, and algebraic and category theoretic methods for invariant systems analysis. Any such theoretical approaches should be linked to compatible strategies which can involve techniques from systems analysis at multiple levels of abstraction, software and hardware modeling languages, software and system interfaces that improve component integration, and new methods for instrumentation and measurement. Application areas of interest, but not limited to: distributed, autonomous, and heterogeneous systems, distributed computational and cloud computing systems, information security applications, and efforts in dynamic resource management. Other related systems examples could be drawn from such diverse areas as quantum, biological, or sociological systems. These application areas should have relevancy to current U.S. Air Force needs.

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5. Information Operations and Security

Program Description: The goal of this program is to provide the science foundation to enable development of advanced cyber security methods, models, and algorithms to support future U.S. Air Force systems. Research is sought to meet the Information Operations challenges of Computer Network Defense, Computer Network Attack and the management of the cyber security enterprise.

Basic Research Objectives: The development of a Science of Cyber Security is the major thrust of this program. The development of the mathematical foundations of system software, hardware, human users and attackers, and network architectures with respect to cyber security (implemented in policy), including key metrics, abstractions, and analytical tools is a critical issue. Formal modeling and understanding of the human users and attackers in these systems is of high interest. Research on how to operate securely on insecure systems is high interest to this program. Developing the theory and methods to operate securely on distributed and cloud systems and systems that may not be secure is of high interest. Development of theory and methods to discover covert channels, side channels, hidden software, and hidden circuits in hardware is of high interest. Research on the theory of the intersection of cyber and electronic warfare is of high interest. Basic research that predicts and anticipates the nature of future information system attacks is of high interest.

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6. Mathematical and Computational Cognition

Program Description: This program supports innovative basic research on high-order cognitive processes that are responsible for human performance in complex problem solving and decision making tasks. The overall objective is to understand these processes by developing and empirically testing mathematical, statistical or computational models of human attention, memory, categorization, reasoning, problem solving, learning and motivation, and decision making. We are especially interested in the development and evaluation of formal cognitive models that provide an integrative and cumulative account of scientific progress, are truly predictive, as opposed to postdictive, and finally, are generalizable beyond controlled laboratory tasks to information-rich and dynamic real-world tasks

Basic Research Objectives: Research to elucidate core computational algorithms such as those that pertain to understanding 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 a benchmark against which human cognitive performance can be measured. Selected examples of such algorithms include (the list is not exhaustive): (1) reinforcement- and machine-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) hierarchical or nonparametric Bayesian algorithms for reasoning, causal inference and prediction, where prior knowledge and data/evidence are optimally combined; (5) active learning algorithms for adaptive information sampling.

In relating formal models to human cognition and performance, research projects should not only ascertain their descriptive validity but also their predictive validity. To this end, the program welcomes the work that (1) creates a statistical and machine learning framework that semi-autonomously integrates model development, evaluation, selection, and revision; (2) bridges the gap between the fields of cognitive modeling and artificial general intelligence by simultaneously emphasizing important improvements to functionality and also explanatory evaluation against specific empirical results. The program also encourages the development and application of novel and innovative mathematical and neurocomputational approaches to tackle the fundamental mechanisms of the brain, that is, how cognitive behavior emerges from the complex interactions of individual neurobiological systems and neuronal circuits. Cross-disciplinary teams with cognitive scientists 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. Robust Decision Making in Human-System Interface

Program Description: The need for mixed human-machine decision making appears at all levels of U.S. Air Force operations and pervades every stage of U.S. 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.

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8. Science of Information, Computation and Fusion

Program Description: The U.S. Air Force collects vast amounts of data through various modes at various times in order to extract and derive needed “information” from these large and heterogeneous (mixed types) data sets. Some data, such as those collected from magnetometers, register limited information content which is more identifiable at the sensor level but beyond human’s sensory reception. Other types of data, such as video cameras or text reports, possess more semantic information that is closer to human’s cognition and understanding. Nevertheless, these are instances of disparate data which encapsulate different types of “information” pertained to, perhaps, the same event(s) captured by different modalities through sensing and collection.

In order to understand and interpret information contained in various data sources, it is necessary to extract relevant pieces of information from these datasets and to make inferences based on prior knowledge. The discovery of relevant pieces of information is primarily a data-driven process that is correlational in nature and, hence, offers point solutions. This bottom-up processing direction needs conceptually-driven reasoning to integrate or fuse the previously extracted snippets of information by leveraging domain knowledge. Furthermore, the top-down process can offer causal explanation or causal inference, generate new hypotheses, verify or test hypotheses in light of observed datasets. Between the data-driven and conceptually-driven ends, there may reside different levels of abstraction in which information is partially extracted and aggregated based on the nature of applications.

Basic Research Objectives: With the rationale and guiding principles outlined in the above paragraph, this program seeks fundamental research that potentially leads to scientific advancements in informatics and computation which can support processing and making sense of disparate information sources. After all, information processing can formally and fundamentally be described as computing and reasoning on various data structures. Successes in addressing the research sub-areas stated below would give the U.S. Air Force new capabilities to: (1) shift emphasis from sensing to information; (2) understand the underpinning of autonomy; (3) relieve human’s cognitive overload in dealing with the data deluge problem; (4) enhance human-machine interface in information processing.

To accomplish the research objectives, this program focuses on, but is not limited to, new techniques in mathematics, computer science, statistics and logic which have potentials to: (1) cope with various disparate and complex data types; (2) construct expressive data structures for reasoning and computation; (3) bridge correlational with causal discovery; (4) determine solutions or obstructions to the local-to-global data-fusion problem; (5) mechanize reasoning

and computing in the same computational environment; (6) yield provably efficient procedures to enable or facilitate data analytics; (7) deal with high-dimensional and massive datasets with provably guaranteed performance.

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9. Sensing, Surveillance and Navigation

Program Description: 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 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.

Basic Research Objectives: 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 searches for 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 sought, 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 it critical to achieve GPS-quality positioning in situations where 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 U.S. 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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10. Systems and Software

Program Description: The AF's mission is to “fly, fight, and win in air, space, and cyberspace.” In order to accomplish its mission, the AF invests in Systems & Software, which is the keystone of all advanced technology. The Systems & Software program actively searches for ideas with respect to two submissions: 1) Improving current AF systems, and; 2) Introducing cutting-edge research to expand the field of knowledge. Improving current AF systems is needed; the AF's use of legacy systems is well known, along with the detrimental issues of legacy system use. There are many AF systems which have extremely long life cycles (such as combat system software). In order to ensure that these legacy systems are up-to-date, new systems infrastructures are investigated. Additionally, new areas of Systems & Software are encouraged to ensure that the AF continues to be on the cutting-edge of technology; novel areas include entirely new directions that will have significant impact in the future. Overall examples of areas include operating systems, compilers, virtual memory, multi-core platforms, etc. AFOSR is looking for research that will drastically improve current AF systems and help to develop new S&T for the benefit of the nation.

Basic Research Objectives: As stated above, Systems & Software addresses two issues – both the new and the old: 1) New Technology Research (such as, but not limiting to, multi-core and many-core systems), and; 2) Legacy System Research (concerning existing AF systems such as, but not limiting to, operating systems, software, etc.). Since Systems & Software direction is continually changing, i.e., technology life-span of approximately 3 years or less, specific subareas are not specifically stated within this BAA; instead, due to the topical nature of the field, the specific area of research is open to the proposer, as long as the research addresses either issue – New Technology Research or Legacy System Research – in Systems & Software. Any new ideas of either of the two issues are welcomed.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

Proposals should be submitted by June 2014; this will allow for a thorough review prior to the start of FY15 which is 1 October 2014.

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11. Trust and Influence

Program Description: The Trust and Influence program is aimed at developing a basic research portfolio that will provide the empirical foundation for the science of reliance and contemporary influence. This R&D portfolio specializes in basic research focused on (1) empirical science of trust in complex human-machine/robot interactions, (2) interpersonal and cross-cultural trust development, maintenance and repair, (3) science of influence effects including the psychological and behavioral impact of novel technology on the battlefield, and (4)

understanding the cognitive and social avenues of influence based on cultural, social, or technological means. The resulting portfolio directly enhances the U.S. Air Force's impact on policies and operations related to national security by investing in the discovery of the foundational concepts of effective influence, deterrence, trust-building, trust calibration with technological systems, counter-terrorism and paths to violent radicalization. The AFOSR trust and influence R&D portfolio specifically invests in multi-disciplinary approaches ranging from psychology to computer science. Research designs that incorporate field research or laboratory research are encouraged to apply as are conceptual studies aimed at developing transformative novel theories.

Basic Research Objectives: This program encourages collaboration between psychologists, neuroscientists, anthropologists, sociologists, linguists, behavioral or cognitive scientists as well as computational researchers in disciplines such as computer science. The basic research interests under this program can be defined broadly by four areas. In the area of Trust there is particular interest in (1) empirical studies to examine drivers of trust calibration between humans and intelligent autonomous agents, and (2) empirical science to reveal the antecedents of trust in interpersonal and cross-cultural interactions. In the area of Perceptual and Social Cues in Human-like Robotic Interactions there is particular interest in (1) laboratory and field studies to examine impact of socially-designed cues such as humanoid appearance, voice, personality, and other social elements on human trust and overall system performance, (2) comparative studies that investigate the impact of physical embodiment features to empirically determine which features have the most influence on human trust behavior, and (3) research on dynamic modeling of human-robotic teaming to allow continuous improvement of joint performance in real-world applications. In the area of Socio-Digital Influence there is a need for (1) laboratory and field studies to examine the relevance, impact and dynamics of social influence tactics in online forums and across different cultural groups, (2) empirical studies to reveal the sources of influence and persuasion in social media, and (3) empirical and theoretical studies to discover new theories of influence as it pertains to the global digital domain. In the area of Psychological and Behavioral Effects of Advanced Weaponry there is interest in (1) empirical studies to describe and understand public perceptions of novel lethal and non-lethal weapons (with a specific emphasis on robotic platforms, uninhabited aerial systems, and/or directed energy technology), (2) cross-cultural studies to investigate potential differences among cultural groups in their perceptions of novel weapon technologies, and (3) modeling and simulation approaches which demonstrate the behavioral and psychological effects of lethal and or non-lethal weapons.

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d. Complex Materials and Devices (RTD):

The Complex Materials and Devices Department leads the discovery and development of the fundamental and integrated science that provides novel options that increase operational flexibility and performance of systems and environments of relevance to the U.S. Air Force. A key emphasis is the establishment of the foundations necessary to advance the integration or convergence of the scientific disciplines critical to maintaining technological superiority. The Department carries out its ambitious mission through leadership of an international, highly diverse, and multidisciplinary research community to find, support and fosters new scientific discoveries that will ensure future novel innovations to transform the U.S. Air Force of the future.

This Department focuses on meeting the basic research challenges by leading the discovery and development of fundamental science and engineering across three integrated research focus areas:

Complex Materials and Structures: Focus on complex materials, microsystems and structures by incorporating hierarchical design and functionality from the nanoscale through the mesoscale, ultimately leading to controlled well understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.

Complex Electronics and Fundamental Quantum Processes: This includes exploration and understanding of a wide range of complex engineered materials and devices, including non-linear optical materials, optoelectronics, Metamaterials, cathodes, dielectric and magnetic materials, new classes of high temperature superconductors, quantum dots, quantum wells, and Graphene. In addition to research into underlying materials and fundamental physical processes, this area considers how they might be integrated into new classes of devices and a fundamental understanding of materials that are not amenable to conventional computational means (e.g., using optical lattices to model high-temperature superconductors).

Natural Materials and Systems Research: This area focuses on multidisciplinary approaches for studying, using, mimicking, or altering the novel ways that natural systems accomplish their required tasks. Nature has used evolution to build exquisite materials and sensors that often outperform manmade versions. This scientific thrust discovers how to mimic existing natural sensory systems, and adds existing capabilities to these organisms for more precise control over their material production.

The program descriptions that follow address specific sub-areas of interest as well as explore novel ideas to bridge disciplines across the research scoped through the three broad areas above. Many critical research activities fostered under the programs discussed here are multidisciplinary and involve support from the other scientific Departments within AFOSR. Research at the interfaces across disciplines often provides insights necessary for and leading to new technological advances. Creativity is highly encouraged in proposing novel scientific approaches for our consideration.

The RTD research portfolios and their program officers are listed here:

- 1) Aerospace Materials for Extreme Environments, Dr. Ali Sayir
- 2) GHz-THz Electronics, Dr. Gernot S. Pomrenke
- 3) Low Density Materials, Dr. Joycelyn Harrison
- 4) Mechanics of Multifunctional Materials and Microsystems, Dr. B.-L. (“Les”) Lee
- 5) Natural Materials and Systems, Dr. Hugh C. De Long
- 6) Optoelectronics and Photonics, Dr. Gernot S. Pomrenke
- 7) Organic Materials Chemistry, Dr. Charles Lee
- 8) Quantum Electronic Solids, Dr. Harold Weinstock

Research areas are described in detail in the Sub areas below:

1. Aerospace Materials for Extreme Environments

Program Description: The objective of basic research in Aerospace Materials for Extreme Environments is to provide the fundamental knowledge required to enable revolutionary advances in future U.S. Air Force technologies through the discovery and characterization of materials for extreme temperatures (exceeding 1000°C), other extreme environments of stress-, magnetic-, electric-, microwave-, and ultrasound fields. Interest domain includes the fundamental science of single crystals, heterogeneous structures, interface of phases and grain boundaries. Materials of interest are ceramics, metals, hybrid systems including inorganic composites that exhibit superior structural, functional and/or multifunctional performance.

Basic Research Objectives: The function within a specific time domain of interest profoundly important and response characteristics defines the material more importantly than generalized properties. The following research concentrations are selected to highlight the aforementioned philosophy about function, environment and state of the materials that could create disruptive source of transformations.

- **Predictive Materials Science:** Simulation-based materials design has the potential to dramatically reduce the need for expensive down-stream characterization and testing. Currently, we don't even have a good grasp of how combining materials into particular compounds gives them certain properties, or how these properties give materials functional qualities. Often the modeling approaches make casual inference about the microstructural features. The aim is to explore the possibility for the quantification of microstructure through reliable and accurate descriptions of grain and particle shapes, and identifying sample distributions of shape descriptors to generate and predict structures which might revolutionize the design and performance. The quality of computerized representation of microstructures and models will be measured by its (a) geometric accuracy, or faithfulness to the physical landscape, (b) complexity, (c) structure accuracy and controllability (function), and (d) amenability to processing and high level understanding. In order to satisfy this objective, the approaches may require development of an accurate methodology for the quantification of 3-Dimensional shapes in both experimental and theoretical microstructures in heterogeneous systems, and to establish a pathway for an accurate comparison tools (and metric).

- ***Materials Response Far from Equilibrium:*** The transformative breakthrough has not originated from the investigations of materials in equilibrium state but in contrary at the margins of the disciplines. In this context, this program embraces materials that are far from the thermodynamic equilibrium domain; bulk metallic glasses, highly doped polycrystalline laser materials, adaptive oxides, multiferroics, supersaturated-, frustrated structures (quasi-two-dimensional electron gas of layered structures). The aim is to link an effective property to relevant local fields weighted with certain correlation functions that statistically exemplify the structure and demonstrate clear scientific pathway to create new materials with specific tailorable properties. This subtopic area require elucidation of complex interplay between (first order) phase transitions for electronic/magnetic phase separation and untangle the interdependence between structural, electronic, photonic and magnetic effects. Realization of the multi-component systems that are far from equilibrium may also require new approaches to how computation itself is modeled or even an entirely new understanding of computation.
- ***Combined External Fields:*** This portfolio stresses a fundamental understanding of external fields and energy through the materials microstructure at a variety of time scales and in a variety of conditions. This area includes a wide range of activities that require understanding and managing the non-linear response of materials to combined loads (i.e., thermal, acoustic, chemistry, shear or pressure fields) under high energy density non-equilibrium extremities. One example of this this objective is the interest to expand the scientific understanding of high electrical field applications through the incorporation of the new mathematical enterprises that captures the dynamic relationship between structure and properties across the space and time scales that exist at the hetero-interface. Another example is the discovery of new techniques for modeling, measuring, and analyzing thermal phenomena at multiple time and length scales in emerging novel material systems with the ultimate goal of exploiting these phenomena to design future materials and components that break the paradigm of today's materials where the boundaries of performance/failure are defined by thermal conduction, convection, and radiation physics. As a whole, this subtopic also aims to expand the scientific base for understanding the formation, control, and mitigation of structures in external fields and use this scientific base to design and build materials far from equilibrium as well as thermodynamically stable structures.

It is important to consider cross-disciplinary teams with material scientist and engineers in collaboration with mathematicians, statisticians, and physicist, and chemist, etc., are encouraged. While single investigator and multidisciplinary team proposals also are encouraged and will be considered on a case by case basis.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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2. GHz-THz Electronics

Program Description: This program seeks scientific breakthroughs in solid-state materials and devices that are vital for game-changing capabilities in sub-millimeter-wave radar, ultra-wideband communications, remote sensing, and ultra-high-speed on-board and front-end data processing. Such capabilities are crucial for long-term U.S. Air Force C4ISR. Research proposals are sought that address high-risk, high-payoff topics having fundamental challenges that are scientifically interesting and technologically relevant.

This research portfolio is divided into three thrusts:

I) THz Electronics: These topics include devices based mainly on covalently bonded semiconductors, such as C, Si, Ge, GaAs, InP, GaN, and related compounds. The main challenges are in perfecting crystals, interfaces, transport paths, and heterostructures, as well as scaling to nanometer dimensions for THz operations, while maintaining adequate device characteristics, such as on/off current ratio, sub-threshold turn-on slope, and breakdown voltage. A subarea of interest includes 2-D materials beyond graphene as enablers for THz electronics, with focus on bandgap engineering and the unique properties of 2-D materials as basic building blocks and on demonstrating 2-D heterostructure devices with unprecedented performance.

II) Novel GHz Electronics: These topics include devices based mainly on ionically bonded semiconductors, such as complex oxides of transition metals. These semiconductors may relax requirements on crystalline perfection, while delivering much higher power than covalently bonded semiconductors can. The main challenges are in understanding mechanisms for high-quality, large-area, and low-cost growth on flexible substrates, as well as in understanding compositional control, doping mechanisms, correlated transport, metal-insulator transitions, and topological insulating properties, especially in p-n and other heterojunctions. Scaling to advance operating speeds from the GHz to the THz range will also be explored.

III) Reconfigurable Electronics: These topics include devices based mainly on non-semiconductors that can perform multiple electronic, magnetic, and optical functions. Devices based on metamaterials, artificial dielectrics, ferrites, multiferroics, nano-magnetics, and micro/nano electromechanical systems for reconfigurable radio-frequency front-ends are of interest. The main challenges are in understanding interactions between electromagnetic waves and electrons, plasmons, and phonons on the nanometer scale. Additional challenges involve the scientific bases for reproducible material preparation and for fabrication of devices that are compact, lightweight, inexpensive, and consume little power.

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3. Low Density Materials

Program Description: Reducing the weight of aerospace platforms reduces costs and emissions while increasing payload capacity and performance. The AFOSR Low Density Materials portfolio supports transformative, basic research in materials design and processing to enable weight reductions with concurrent enhancements in performance and function. Such materials can transform the design of future U.S. Air Force aerospace and cyber systems for applications which include airframes, space vehicles, satellites, and load-bearing components and systems. Key scientific areas supported by the program include: materials discovery, processing and characterization; nanotechnology; integrated computational material science and engineering; composite and hybrid materials processing; and interface/phase science.

Among the routes to achieving game-changing improvements in low density materials currently emphasized within the program are 1) materials discovery and processing to increase performance properties of structural materials, e.g., matrix resins and reinforcing fibers and nanoparticulates; 2) multiscale modeling of material degradation mechanisms to improve material life prediction capability and minimize overdesign of load-bearing structures; 3) understanding the impact of nanoscale porosity on mechanical properties; and 4) the creation and interfacial understanding of hybrid structures that combine materials of different classes, scales, and properties to provide synergistic and tailorable performance.

Basic Research Objectives: Proposals are sought that advance our understanding of hierarchical or hybrid materials and our ability to design, model and fabricate multi-material, multi-scale, multi-functional material systems with a high degree of precision and efficiency. Fundamental research targeting materials that may engender multifunctionality such as high strength plus electrical and thermal transport properties and/or adaptivity to enable active aerospace structures is also a keen program interest. Material classes may be polymeric, ceramic, or metallic, possibly combining synthetic and biological species to engender lightweight structural integrity and multifunctionality.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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4. Mechanics of Multifunctional Materials and Microsystems

Program Description: The main goals of this program are (a) to promote the utilization of newly emerging materials, nano-devices and microsystems in multifunctional design of advanced structures for higher system efficiency, (b) to bridge the gap between the viewpoints from materials science on one side and structural engineering on the other in forming a scientific basis for the materials development and integration criteria, and thereby (c) to establish safer,

more maneuverable aerospace vehicles and platforms with unprecedented performance characteristics.

Basic Research Objectives: Specifically, the program seeks to establish the fundamental understanding required to design and manufacture new aerospace materials, nano-devices 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 the ability to carry the load, durability, reliability, survivability and maintainability in response to the changes in surrounding environments or operating conditions. Among various visionary contexts for developing multifunctionality, the concepts of particular interest are: (a) “autonomic” structures which can sense, diagnose and respond for adjustment with minimum external intervention, (b) “adaptive” structures allowing reconfiguration or readjustment of functionality, shape and mechanical properties on demand, and (c) structural integration of power harvesting/storage/transmission capabilities for “self-sustaining” system. This program thus focuses on the development of 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 U.S. 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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5. Natural Materials and Systems

Program Description: The goals of this multidisciplinary program are to study, use, mimic, or alter how living systems accomplish their natural functions or to take those biomaterials and systems and use them in new ways such as seen with bionanotechnology. Nature has used evolution to build materials and sensors that outperform current sensors such as a spider’s haircells that can detect air flow at low levels even in a noisy background. Nature is very good at solving the problem of working in a noisy environment. 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 three general areas: biomimetics, biomaterials (non-medical only), and biotic/abiotic interfaces.

Basic Research Objectives: Biomimetics 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 biomaterials area (doesn't include any medical materials work) 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. We are also interested in organisms that disrupt or deny a material's function or existence in some way.

The biointerfacial sciences 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 the nanoscale to mesoscale 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 (biophotonics).

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6. Optoelectronics and Photonics

Program Description: This program supports Air Force requirements for information dominance by increasing capabilities in image and data capture, processing, storage, and transmission for applications in surveillance, communications, computation, target discrimination, and autonomous navigation. 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 with low power, low weight, and small sized components. Five major areas of interest include Integrated Photonics (including Silicon Photonics); Nanophotonics (including Plasmonics, Photonic Crystals, Metamaterials, Metaphotonics and Novel Sensing); Reconfigurable Photonics (including all-optical switching and logic, and optoelectronic computing); Nanofabrication, 3-D Assembly, Modeling and Simulation Tools for Photonics; and Quantum Computing using Optical Approaches.

Basic Research Objective: The major objective is to push the frontiers of optics and explore new fundamental concepts in photonics; understand light-matter interactions at the sub-wavelength and nano-scale; investigate novel optoelectronic materials; improve the fundamental understanding of photonic devices, components, and architectures; and enable discovery and innovation in advancing the frontier of nanophotonics with the associated nanoscience and nanotechnology.

The thrusts in Integrated Photonics 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 technology approaches (such as silicon photonics, tin based Group IV photonics, Graphene and related 2D materials and novel III-V optoelectronics) are part of the program as are techniques for optoelectronic integration.

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 and 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, quantum plasmonics and quantum Metamaterials, plus novel approaches to ultra-low power optoelectronic devices.

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. 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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7. Organic Materials Chemistry

Program Description: The goal of this research area is to achieve unusual properties and behaviors from polymeric and organic materials and their inorganic hybrids through a better

understanding of their chemistry, physics and processing conditions. This understanding will lead to development of advanced organic and polymeric materials for future U.S. Air Force applications. This program's approach is to study the chemistry and physics of these materials through synthesis, processing control, characterization and establishment of the structure properties relationship of these materials. There are no restrictions on the types of properties to be investigated but heavy emphases will be placed on unusual, unconventional and novel properties. Research concepts that are novel, high risk with potential high payoff are encouraged. Both functional properties and properties pertinent to structural applications will be considered. Materials with these properties will provide capabilities for future Air Force systems to achieving global awareness, global mobility, and space operations.

Basic Research Objectives: Proposals with innovative material concepts that will extend our understanding of the structure-property relationship of these materials, discover previously unknown properties and/or 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. Material concepts for power management, power generation and storage applications are of interest. 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, third order nonlinear optical materials, electrooptic polymers, liquid crystals, photorefractive polymers and magneto-optical polymers. Examples of electronic properties of interest include conductivity, charge mobility, electro-pumped lasing and solar energy harvesting. Controlled growth and/or self-assembly of nanostructures into well-defined structures (e.g. carbon nanotubes with specific chirality) or hierarchical and complex structures are encouraged. Organic based materials, including inorganic hybrids, with controlled magnetic permeability and dielectric permittivity are also of interest. Material concepts that will provide low thermal conductivity but high electrical conductivity (thermoelectric), or vice versa, (thermally conductive electrical insulator) are of interest. Nanotechnology approaches are encouraged to address all the above-mentioned issues. Approaches based on biological systems or other novel approaches to achieve material properties that are difficult to attain through conventional means are encouraged.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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8. Quantum Electronic Solids

Program Description: This program focuses on materials that exhibit cooperative quantum electronic behavior. The primary emphasis is on superconductors, metamaterials, and on

nanoscopic electronic devices based mainly upon graphene, nanotubes and other forms of carbon 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 U.S. Air Force electronic systems.

Basic Research Objectives: The superconductivity portion of this program is almost entirely devoted to a search for new classes of superconducting materials that either have higher transition temperatures, higher critical magnetic fields or have isotropic superconducting properties at temperatures in the range of the transition temperatures of the cuprates, e.g., YBCO. While the 2008 discovery of iron-pnictide superconductors has provided new insights, these materials are not sufficiently promising. This emphasis is 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. However, major awards under this program were made in FY09, so while any promising new ideas will be considered, funding for new projects in this area will be somewhat limited in the near future. The program is primarily an experimental one, but theorists who interact with experimental groups constructively are welcome. The primary goal of this part of the program is to uncover superconducting materials that can be made into forms that are amenable to U.S. Air Force applications.

The metamaterials portion of this program is devoted to the production of metamaterials that operate over a wide swath of the electromagnetic spectrum, from microwaves, to IR and the visible. The long-term 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 important aspect is to study the ability to create sub-wavelength, near-field (and possibly far-field) imaging. These desired properties could lead to denser information storage and retrieval.

A relatively new area of interest involves thin-film, oxide-based materials that are critical for the development of devices with new functionalities that will lead to useful, reprogrammable, controllable and active systems at the nanoscale with properties difficult to attain by other means. The utilization of oxides for revolutionary technologies critically relies on acquiring fundamental understanding of the physical processes that underlie spin, charge and energy flow in these nanostructured materials. The oxides to be considered are generally complex, multi-element materials that can be synthesized in unusual nanostructured geometries that exhibit strong electronic correlations.

A relatively minor part of this program is the inclusion of nanoscopic techniques to fabricate, characterize, and manipulate atomic, molecular and nanometer-scale structures (including graphene, and nanotubes of carbon and other elements), 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 aspect of the program 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.

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e. Energy, Power and Propulsion Sciences (RTE):

The Energy, Power and Propulsion Sciences Department leads the discovery and development of innovative fundamental science addressing a broad spectrum of energy-related issues. The overarching goal of the department is to discover and exploit the critical knowledge and capabilities that will shape the development of energetically-efficient future U.S. Air Force systems. In pursuit of this goal, the Department proactively directs an international, highly diverse and multidisciplinary research community to find, support and foster new scientific knowledge that will provide the foundation for unprecedented energy efficiency in future systems.

The research supported by the Energy, Power and Propulsion Sciences Department spans a considerable set of topics ranging from biological systems to space propulsion, with the following research emphasis areas shared by many of the contributing portfolios:

Discovery and Development of Energy Sources: Research in this area emphasizes the identification and characterization of key fundamental phenomena that will provide the scientific foundation for revolutionary advancements in energy sources and conversion processes. A broad spectrum of research topics contribute to progress in this area, including, but not limited to: biologically-derived energy sources; innovative chemical formulations and synthesis; combustion enhancement; and scientific foundations for revolutionary propulsion concepts.

Fundamental Mechanisms of Energy Transfer: Research in this area emphasizes the identification, characterization and modeling of energy transfer between various energetic modes in a heterogeneous environment and across media boundaries. Representative topics of interest include, but are not limited to: phonon dynamics in heterogeneous media; transfer of energy between kinetic, internal and chemical states in gasses; biological interactions between living and non-living systems, and interactions between nonequilibrium environments and reactive surface boundaries.

Within the Department special emphasis is placed on the identification and development of multidisciplinary research opportunities where advancements and insight originating in one discipline may inspire and drive innovative progress in another.

The RTE research portfolios and their program officers are listed here:

- 1) Aerothermodynamics, Dr. John Schmisser
- 2) Energy Conversion and Combustion Sciences, Dr. Chiping Li
- 3) Human Performance and Biosystems, Dr. Patrick O. Bradshaw
- 4) Molecular Dynamics and Theoretical Chemistry, Dr. Michael Berman
- 5) Space Power and Propulsion, Dr. Mitat A. Birkan
- 6) Dynamic Materials and Interactions, Dr. Jennifer Jordan

Research areas are described in detail in the Sub areas below:

1. Aerothermodynamics

Program Description: The objective of the Aerothermodynamics portfolio is to develop the fundamental scientific knowledge of high-speed, nonequilibrium flows required for revolutionary advancements in a broad variety of future U.S. Air Force capabilities including energetically-efficient air and space systems, rapid global and regional response, and thermal/environmental management. Research supported by this portfolio seeks to discover, characterize and leverage fundamental energy transfer mechanisms within high-speed flows and at gas-surface interfaces through a balanced mixture of investments in experimental, numerical and theoretical efforts.

Basic Research Objectives: Innovative research is sought in all aspects of high-speed nonequilibrium flows with particular interest in efforts that explore the dynamics and mechanisms for energy transfer between the kinetic, internal and chemical modes of the gas. Efforts that leverage recent breakthroughs in other scientific disciplines to foster rapid research advancements are also encouraged. Topics of interest include, but are not limited to, the following:

- Characterization and modeling of the coupled dynamics, thermodynamics and chemistry of nonequilibrium flows, driven by rate-dependent fundamental processes.
- Innovative insight into the control and exploitation of energy transfer within the flowfield is of particular interest. (Note: Combustion processes are addressed by other portfolios and are not within the scope of interest.)
- Shock/Boundary Layer and Shock-Shock Interactions
- Characterization and modeling of fundamental processes occurring between nonequilibrium flows and reactive surfaces.

Aerothermodynamic research is critical to the U.S. Air Force's interest in long-range and space operations. The size, weight, and performance of many systems, are strongly influenced by Aerothermodynamic considerations. Research areas of interest emphasize the characterization, prediction and control of critical phenomena which will provide the scientific foundation for game-changing advancements in aerodynamics, environmental (thermal and acoustic) management, propulsion, and directed energy.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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2. Energy Conversion and Combustion Sciences

Program Description: This portfolio addresses energy needs for operating propulsion systems and their supporting sub-systems. The portfolio emphasizes fundamental and relevance, focusing on establishing fundamental understanding and quantifying rate-controlling processes in energy conversion processes, leading to game-changing concepts and predictive capabilities in Air Force relevant regimes. Multi-disciplinary collaborations and interactions are strongly desired, and joint experimental, theoretical and numerical efforts are highly appreciated.

Basic Research Objectives: Research proposals are sought in all aspects of energy conversion research, combustion and related topics, with the following emphases:

(1) Turbulent Combustion: the primary energy conversion process in most existing propulsion systems such as jet engine, rocket, hypersonic and large UAV systems. It is one of most important factors in determining operability, performance, size and weight of such systems. It is also one of least understood areas in basic combustion research with, in general, rather large model/prediction uncertainties. In this area, the research focus is on quantifying rate-controlling processes and scales. Proposals will be considered with priority in the following areas:

- Understanding key turbulent combustion phenomena: Including but not limited to: flame structure and propagation, flammability limit and combustion instability, at multi-phase fueling conditions. In such proposed efforts, understanding, quantifying and controlling turbulence properties at corresponding flow conditions are essential. Those conditions should be relevant to Air Force propulsion interests, with emphases on highly-turbulent, high-pressure, multiphase conditions.
- Establishing foundation for predictive modeling: focusing on validating as directly as possible and further developing basic model assumptions used in the numerical simulation for turbulence combustion with the particular emphasis on understanding and quantifying impacts of combustion and fluid processes at sub-grid scales on those at LES resolvable scales, leading to the scientific foundation for building and validating sub-grid turbulent combustion models;
- Diagnostics for (1) New game-changing signal generating processes and related basic spectroscopic approaches for key properties in multiphase chemically reacting flows and (2) High-frequency, 3-d (volumetric or scanning 2-d) imaging for transient, turbulent flame and flow structures at required temporal and spatial scales;
- Numerical algorithms and tools for (1) Addressing specific needs in simulations for the turbulent reacting flows due to its complex multi-physics nature and (2) Combined experimental-numerical approaches using simulations directly coupled with experimental data to reduce the simulation uncertainty and to obtain quantitative information which is otherwise not available through experimental measurements alone.

(2) Combustion Chemistry: the key element governing the chemistry of combustion process. The research focus is on developing physics-based approaches for identifying rate-controlling reaction pathways and generating combustion chemistry models of quantifiable and acceptable uncertainty with reasonable size for the turbulent, reactive flow simulation. Emphasized areas are as follows:

- The first principle based, theoretical and computational to studying and identifying stochastic pathways in complex combustion chemical reaction systems;
- Ab initio constrained approaches for optimization and reduction of combustion chemistry models;
- Diagnostics: (1) Ultra-fast approaches (e.g. using ultra-short pulse laser) for observing ultra-fast events such as those in initial break-up of fuel molecules crucial to identifying key reaction pathways and (2) Other necessary experiments for identifying reaction pathway and quantifying model parameters;
- Quantifying the uncertainty of research approaches in combustion chemistry, especially that due to the empiricism with the purpose of minimizing such empiricism, and understanding relationship between the model size and model uncertainty.

(3) Game-Changing Energy Conversion Concepts and Multi-Functions Energy Conversion Processes: Potential areas include but not limited to:

- Combustion at extreme time-scales such as detonation and flameless/ mild combustion;
- Innovative thermal-dynamic cycles, particularly for UAVs;
- Non-thermal, reduced-thermal, hybrid energy conversion processes for future propulsion and subsystems.
- Multi-functional energy conversion processes: (1) Understanding and Quantification of energy needs and conversion processes in propulsion-supporting subsystems such as resource supplies, control, sensing and information processing as well as guidance and navigation and (2) Approaches and algorithms for minimizing energy consumption of those sub-systems;
- Multi-functional fuels: (1) Endothermic fuels and systems and (2) Aviation fuels and energy systems with favorable source characteristics.

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3. Human Performance and Biosystems

Program Description: The U.S. Air Force is currently interested in improving human capabilities through the development of advanced human-machine interfaces and the establishment of direct methods used to augment human performance. The primary goal for this program is to gain a better understanding of the biophysical, biochemical, and physiological mechanisms responsible for the behavioral, tissue, cellular and genetic effects resulting from various forms of bio-stimulation. Recently, extremophiles has been added to this program. Additionally, a sensory systems focus has been added in this program and the emphasis is on developing the basic scientific foundation to understand and emulate sensory information systems. Emphasis is on (a) acoustic information analysis, especially in relation to human auditory perception, and (b) sensory and sensorimotor systems that enable 3D airborne navigation and control of natural flight, e.g., in insects or bats, especially in relation to capabilities of autonomous biological systems not yet emulated in engineered flight.

Basic Research Objectives: This program is interested in defining the mechanisms (cognitive, neural, genetic, physiological, biological etc.) associated with enhancing human capabilities as well as understanding the associated biomarkers, bio-circuits, bioelectric and connection pathways involved with increasing performance capabilities especially as they relate to aircrew member performance. In addition, this program aims to explore natural and synthetic processes, mechanisms and/or pathways for understanding energy production in Biosystems. We are also interested in understanding the variables of fatigue and toxicology as they relate to performance decrement in the aviation environment i.e. exploring the bio-circuitry, biochemical and molecular pathways and processes that generate signals associated with fatigue or performance changes. The mechanism associated with the effects of photo-electro-magnetic stimulation as they relate to performance change is of interest to us. We wish to define and understand the biomarkers and genetic changes associated with human performance decrement after the administration of toxicological agents, specific interest in toxicology mechanisms that may or may not exhibit toxic effects at a minimal dose level and toxicological effects of flight line equipment. Proposals aimed at the understanding of synthetic biological process as they relate to energy production in Biosystems (specifically enzymatic and microbial fuel cells as well as photosynthesis) will be accepted.

The extremophiles area is focused on discovering and understanding basic natural mechanisms used by organisms that could be used to either harden or repair soft material-based devices. This will enable the U.S. 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, and enzymatic engineering for faster catalysis in materials identification or degradation.

For the sensory systems portion of the portfolio, one program goal is to pursue new capabilities in acoustic analysis, to enhance the intelligibility and usefulness of acoustic information. The

primary approach is to discover, develop, and test principles derived from an advanced understanding of cortical and sub-cortical processes in the auditory brain. Included are efforts to model and control effects of noise interference and reverberation, understand the psychoacoustic basis of informational masking, develop new 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 approaches based upon auditory system concepts that emphasize higher-level neural processes not yet fully exploited in engineered algorithms for acoustic information processing. Applicants are encouraged to develop collaborative relationships with scientists in the Air Force Research Laboratory (AFRL).

Another program goal is to deepen the scientific understanding of the sensory and sensorimotor processes that enable agile maneuvering and successful spatial navigation in natural flying organisms. Emphasis is on the discovery of fundamental mechanisms that could be emulated for the control of small, automated air vehicles, yet have no current analogue in engineered systems. Recent efforts have included investigations of information processing in wide field-of-view compound eye optics, receptor systems for linear and circular polarization sensing, and mathematical modeling of invertebrate sensorimotor control of path selection, obstacle avoidance and intercept/avoidance of moving targets. All of these areas link fundamental experimental science with neuromorphic or other mathematical implementations to generate and test hypotheses. Current efforts also include innovations in control science to explain and emulate complex behaviors, such as aerial foraging and swarm cohesion, as possible outcomes of simpler sensory-dominated behaviors with minimal cognitive support.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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4. Molecular Dynamics and Theoretical Chemistry

Molecular Dynamics

Program Description: This program seeks a molecular-level description of reaction mechanisms and energy transfer processes related to the efficient storage and utilization of energy. The program supports cutting-edge experimental and joint theory-experiment studies that address key, fundamental questions in these areas. There are four major focus areas in the program: Catalytic Reactivity and Mechanisms; Novel Energetic Material Concepts; Dynamics of Energy Transfer and Transport; and Chemistry in Extreme Environments.

Basic Research Objectives: The molecular dynamics program seeks to understand, predict, and control the reactivity and flow of energy in molecules in many areas of interest to the U.S. Air

Force. Thus, the program encourages novel and fundamental studies aimed at developing basic understanding and predictive capabilities for chemical reactivity, bonding, and energy transfer processes. Some of the program's current interests focus on molecular clusters and nanoscale systems in catalysis, and as building blocks for creating novel materials. Understanding the catalytic mechanisms needed to produce storable fuels from sustainable inputs and to improve propulsion processes are also topics of interest, as are novel properties and dynamics of ionic liquids. Work in this program addresses areas in which control of chemical reactivity and energy flow at a detailed molecular level is of importance. These areas include hyperthermal and ion-chemistry in the upper atmosphere and space environment, plasma-surface interactions, the identification of novel energetic materials for propulsion systems, and the discovery of new high-energy laser systems. The coupling of chemistry and fluid dynamics in high speed reactive flows, and in particular, dynamics at gas-surface interfaces, is also of interest. The program is also interested in utilizing plasmonics, and laser excitation to control reactivity.

Theoretical Chemistry

Program Description: The theoretical chemistry program supports research to develop new methods that can be utilized as predictive tools for designing new materials and improving processes important to the U.S. Air Force. These new methods can be applied to areas such as the structure and stability of molecular systems that can be used as advanced propellants; molecular reaction dynamics; and the structure and properties of nanostructures and interfaces. We seek new theoretical and computational tools to identify novel energetic molecules or catalysts for their formation, investigate the interactions that control or limit the stability of these systems, and help guide synthesis by identifying the most promising synthetic reaction pathways and predicting the effects of condensed media on synthesis.

Basic Research Objectives: The program seeks new methods in quantum chemistry to improve electronic structure calculations to efficiently treat increasing larger systems with chemical accuracy. These calculations will be used, for example, to guide the development of new catalysts and materials of interest. New approaches to treating solvation and condensed phase effects will also be considered. New methods are sought to model reactivity and energy transfer in molecular systems. Particular interests in reaction dynamics include developing methods to seamlessly link electronic structure calculations with reaction dynamics, understanding the mechanism of catalytic processes and proton-coupled electron transfer related to storage and utilization of energy, 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 U.S. Air Force systems. Interest in molecular clusters, nanostructures and materials includes work on catalysis and surface-enhanced processes mediated by plasmon resonances. This program also encourages the development of new methods to simulate and predict reaction dynamics that span multiple time and length scales.

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5. Space Power and Propulsion

Program Description: Research activities are focused as multi-disciplinary, multi-physics, multi-scale approach to complex problems, and fall into four areas: Coupled Material and Plasma Processes Far From Equilibrium, Nanoenergetics, High Pressure Combustion Dynamics, and Electropray Physics

Basic Research Objectives: Research in the first area is to significantly advance the state-of-the-art in our ability to understand the fundamental aspects of a coupled plasma/material system in non-equilibrium states, for a variety of potential applications. The typical conditions of interest are characterized by critical phenomena in small spatial and temporal scales which affect the behavior over a much wider range of scales. Detailed understanding and control of non-equilibrium and multiscale effects have the potential to overcome the limitations of traditional plasma in thermodynamic equilibrium, leading to improved system designs; preventing or leveraging dynamic features such as instabilities, coherent structures, and turbulence; and realizing chemical pathways, structural changes or electromagnetic processes for novel devices with unprecedented level of control. Research in second area is the ability to possess smart, functional nano-energetics for propulsion purposes only. There has been tremendous progress in the synthesis and fabrication of nanosized reactive materials. With significant advances in quantum chemistry and molecular dynamics over the last decade, as well as a broader understanding of the properties of nanomaterials, it may now be feasible to design a priori nanostructured reactive materials to perform a given function and then produce them in the laboratory according to the design, in order to avoid simply reacting in an uncontrolled fashion. Smart nanoenergetics may be activated by temperature, pressure, the presence of a particular chemical compound, or external electromagnetic stimuli, such as an electrical field or light. By smart, it may be desirable to initiate a reaction at a particular temperature, to release a particular compound at a particular temperature, to turn on or turn off a reaction, have tailored ignition properties, or to accelerate or slow a reaction with time or location. Research in the third area is to allow the Air Force to capitalize on the higher efficiencies, and increased performance options made possible by taking rocket and other propulsion systems to increasingly extreme pressures. As this necessarily pushes materials and structures to correspondingly extreme limits, it becomes essential to take into consideration the dynamics of combustion processes, because higher pressures lead to increasing coherent dynamic aerothermochemical events that convert thermal energy to thrust in a wider spectrum of time scales. Mathematical and experimental analysis also leads to a "big data" problem. It becomes necessary to combine and dynamically integrate multi-fidelity simulations and experimental probing or monitoring to systematically perform modeling, analytics, stochastic modeling, and dynamic data driven validation for chemical propulsion. Research in fourth area involves charged droplets and molecular ions that are emitted from the meniscus of a conducting liquid due to a strong electric field. A sufficiently strong electrostatic stress can cause either of two behaviors: (1) an aerosol of charged liquid droplets can be extracted from the surface and accelerated away by the field, or (2) single molecular or atomic ions can be 'field evaporated' from the liquid into the gas phase and accelerated away by the field. Research is sought to control multiphase liquid electropray that can be used for nanoenergetic material processing, propulsion, and other applications.

All fundamental research ideas relating to space propulsion and power are of interest to this program in addition to the examples given above, but researchers should also consult the programs in Plasma and Electro-Energetic Physics, Aerospace Materials for Extreme Environments, Theoretical Chemistry and Molecular Dynamics, Thermal Sciences, Computational Mathematics, and other programs as described in this Broad Area Announcement to find the best match for the research in question. Researchers are highly encouraged to consult (<https://community.apan.org/afosr/w/researchareas/7459.space-power-and-ropulsion.aspx>), for the latest information.

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6. Dynamic Materials and Interactions

Program Description: The objective of the Dynamic Materials and Interactions portfolio is to develop fundamental scientific knowledge of the dynamic chemistry and physics of complex materials, particularly energetic materials. This is required for revolutionary advancements in future Air Force weapons and propulsion capabilities including increased energy density and survivability in harsh environments. Research supported by this portfolio seeks to discover, characterize, and leverage fundamental chemistry, physics, and materials science associated with energetic materials through a balanced mixture of experimental, numerical, and theoretical efforts.

Basic Research Objectives: Research proposals are sought in all aspects of the chemistry and physics of energetic materials with particular emphasis placed on chemistry-microstructure relationships and the exploitation of fundamental shock and detonation physics. Efforts that leverage recent breakthroughs in other scientific disciplines to foster rapid research advancements are also encouraged. Topics of interest include, but are not limited to, the following:

- Mesoscale experiments, and associated models, to understand hot spots and initiation in energetic materials
- Detonation physics, particularly the steady state reacting front propagating in energetic materials
- High strain rate and shock response of polymers, composites, and geologic materials
- Shock loading and mechanical response of energetic crystals
- High energy density materials that overcome the CHNO limitations, including scale-up techniques required for gram-scale characterization of materials.
- Metastable, high pressure phases that have enhanced energy release or other interesting properties
- Influence of external fields, e.g. thermal, electromagnetic, on the behavior of energetic materials
- Prediction of viscosity and microstructure in highly loaded suspensions

Energetic materials research is critical to the development of next-generation Air Force weapon capabilities. The energy content and sensitivity of these systems are influenced by the energetic materials utilized. Research areas of interest emphasize the characterization, prediction, and control of critical phenomena which will provide the scientific foundation for game-changing advancements in munitions development and propulsion.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three to five year effort.

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f. Basic Research Initiatives (BRIs):

This section outlines cross-cutting multi-disciplinary topics that support AFOSR's Basic Research Initiatives (BRI's). These BRI's are new research opportunities of interest to AFOSR. Proposers are highly encouraged to confer with the appropriate AFOSR Program Officer. **Submission of proposals by June 30, 2014 is encouraged. Proposals received after June 30, 2014 may not be evaluated or receive further consideration.**

1. Design and Control of Energy Transfer Pathway
2. Dynamic Material Interfaces in Extreme Environments
3. Chemical Reactions and Collisional Processes of Ultracold Molecules
4. Fundamental Studies of Glass and Ceramics for High Average Power Lasers and Other Applications
5. *In-situ* Dynamic Mesoscale Measurements of Reacting Energetic Materials
6. Molecular Electronics Enabled Control of Cellular Systems (Cyborgcell)
7. Muscular-Skeletal System Inspired Morphing Air Vehicles Using Active Materials
8. Predictive Probabilistic Representation and Fusion Approaches for Resident Space Objects

1. Design and Control of Energy Transfer Pathways

Background: Energy transfer in condensed media can control or limit the efficiency of important technologies ranging from solar cells and photosynthesis to optically active polymers. Important developments have recently been made in understanding how these energy transfer and transport properties can be controlled. These advances include novel structures such as resonances that depend on size, shape and composition of nanostructures or processes such as persistent coherences, non-adiabatic coupling or spin-orbit coupling that can significantly affect energy transport. A unique and timely opportunity is emerging to develop architectures and processes to engineer and control the flow of energy in condensed-phase materials and overcome bottlenecks that limit our current energy storage, harvesting, and transport technologies. These fundamental advances could improve devices from photovoltaics to lasers.

The current opportunity arises from the conjunction of several new discoveries that can be brought together at this time to pursue these new directions in chemistry, materials science, and

even quantum biology. One recent advance of great international scientific interest and debate is the mechanism by which internal energy states can be engineered to affect energy transfer via coherence or non-adiabatic interaction of vibrational and electronic energy levels. In the case of coherences, synthetic structures recently have been created with rigid linkers that control the relative orientation between chromophores to permit efficient and coherent energy transfer as has been observed in systems ranging from small molecules to photosynthetic systems. Tuning nearby electronic states into resonances using non-adiabatic coupling with vibrational levels has also been shown to be a viable mechanism for controlling energy flow and bypassing potential trap states. The use of quantum dots and other nanostructures can also create energy transport pathways that can be controlled by size, and orientation.

Excited state engineering is another effective means to control not only the pathway of intramolecular flow, but also in intermolecular systems as well. Such control can be achieved not only by controlling the relative positions and energy levels of the excited states, but also by the control of intersystem crossing rate and excited state life time, spin-spin interaction and Columbic interaction of the spins and the radicals, exciton diffusions and dissociations, and spatial distance control of different energy centers. The excited state engineering approach can also be used to control the transport of energy through organic-inorganic interfaces.

Objective: In this initiative, we seek to develop methods to control energy flow in materials or complex systems. The energy can be transported via optical, electronic, excitonic, or phononic means, or even a combination of the above. For example, one major goal is to develop methods to design and control energy transfer pathways in order to bypass possible loss mechanisms, e.g. electronic sites that trap excitons and would lead to exciton recombination. This goal of efficient energy transfer can be accomplished by novel design of the structure and energy levels of the material or system, or by processes that guide the flow of energy through unique pathways and processes.

Concentration Area: Research on understanding and controlling energy transfer pathways in materials impacts several concentration areas: molecular and material engineering of energy levels and energy transfer pathways in materials; using optical excitation to control energy flow processes to avoid losses and improve efficiency; developing new spectroscopic methods to decipher which states are participating in energy transfer processes; theoretical methods to model, simulate, and predict the interaction of states that affect energy transfer in condensed media. These components are tightly intertwined, as theory might predict new ways that nanostructures can be designed that will have to be realized by synthesis and probed by spectroscopy. Advances are needed in ways to control energy level positions and interactions in bulk materials and in nanoparticles, spectroscopic methods that probe the interaction of electronic excited states and how they mix and interact on the picosecond and femtosecond time scales, and how energy is lost at particular trap sites and how those traps can be avoided. Theory will be utilized to understand the types of interactions and processes that can bypass energy traps and produce efficient energy transport. Experimental efforts to design material systems for demonstrating and implementing specific energy guidance strategies are encouraged.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2M per year in the research supported by this initiative. Proposals submitted under this initiative should

support small teams of typically 2-4 investigators with awards of up to approximately \$500K per year for 3 years. International collaborations are eligible for consideration.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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2. Dynamic Material Interfaces in Extreme Environments

Background: A range of technologies critical to Air Force and national interests – such as those providing capabilities for space-access propulsion, munitions, and atmospheric entry – involve the interaction between a high-temperature, non-equilibrium environment and a thin layer of reacting composite material, i.e. dynamic reacting interfaces. Examples of these interfaces can be seen in explosives and other energetic materials, thermal protection systems for high-speed vehicles, and internal flows within solid-rocket motors. In these diverse applications, the energy and mass transport across the interface are occurring at comparable rates and pressures. For such interactions, a thin reacting layer occurs as the surface of the composite material is consumed in the extreme environment composed of a mixture of high-temperature external gases and reactive gases created from the responsive material.

In these extreme environments, the morphology and microstructure of both the bulk material and the reacting interface are critical to the resultant behavior of the dynamic interface. The individual states and interactions between the three regimes (high energy gaseous products, dynamic reacting interface, and bulk solid) in this system must be understood to ultimately characterize and control the dynamic reaction rate. Recent progress in the numerical simulation of non-equilibrium gas-solid interfaces, including the utilization of molecular dynamics and mesoscale simulations, creates an opportunity to explore the response of the reacting material interface. However, the critical rate limiting steps in these reaction processes have not been identified. The integration of advanced numerical simulation with well-resolved experiments at extremely short length and time scales has the potential to create new insights into the basic mechanisms of dynamic reacting interfaces, which will advance the state-of-the-art in diverse fields of high priority to the Air Force.

Objective: The objective of this research is to understand and ultimately control the reaction rates of dynamic material interfaces by advancing numerical simulation and experimental validation of material interfaces in a non-equilibrium environment such that the detailed chemical, thermal and mechanical response of a material exposed to extreme dynamic boundary conditions may be accurately characterized and modeled.

Research Concentration Areas: Suggested research areas include but are not limited to:

1) Identification and modeling of the role of material microstructure both in local interactions and in global reactions;

- 2) Characterization and modeling of coupling between the gaseous environment and the reacting material interface;
- 3) Development and utilization of required diagnostic and numerical methods; and
- 4) Fundamental investigation of chemical, microstructural and morphological material changes from surface to bulk material under dynamic reacting conditions.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2M/year in the research supported by this initiative. Proposals submitted under this initiative should support teams of typically 2-4 investigators with awards ranging from \$500K - \$1M/year for three years. International participation is encouraged by through membership in a larger US-based team or by submission of a single-investigator proposal (\$40-70K/year for one-to-three years).

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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3. Chemical Reactions and Collisional Processes of Ultracold Molecules

Background: Over the past five years a quiet revolution has been building at the border between atomic physics and experimental quantum chemistry. The rapid development of techniques for producing cold molecules has opened the possibility of the study of their chemical reactions with unprecedented control of initial quantum states and orientation. Newly developed cooling methods permit the study of molecules in one or a few specific quantum states reacting with other molecules in environments unperturbed by solvent or matrices, and enables the observation and even full control of state-to-state collision rates. This control opens the door to perhaps the most elementary study possible of scattering and reaction dynamics, isolating the individual forces that control the approach of reactants and their interactions. To exactly understand how one specific quantum state of an atom or molecule reacts with another atom or molecule lies at the heart of chemistry and underpins theories and models of chemical reactivity. Before the development of ultracold molecules that could be manipulated by electric and magnetic fields, a knowledge of reacting species required integrating over all possible quantum states in the system. Now their individual role can be potentially assessed and used to favor selective paths. The remarkable recent demonstrations of laser cooling and trapping of SrF, evaporative cooling of OH, magnetic slowing and trapping of buffer-gas cooled CaF, and production of near-zero-velocity high-flux beams of polyatomic molecules using centrifuge deceleration all point to a new era in quantum chemistry. The success of these experiments opens the door to generating other chemically interesting molecular gases in the quantum regime in the future and studying chemical reactions with unprecedented control.

Objective: The goal of this program is to uncover the details of chemical reactions and molecular collisions to an unprecedented degree by studying these processes in the quantum regime with cold and ultracold molecules. With an exquisite control of the quantum states of the

reacting species, thus eliminating thermal distribution of states, quantum chemistry theories can be tested more precisely than before, and new insights on the forces governing chemical reactions are expected to be gained. Experimental investigations are expected to provide foundations for new theories as well, particularly in the case of the role of collective effects and strong correlations in quantum chemistry.

Concentration Area: In this initiative, we seek to investigate quantum chemistry both theoretically and experimentally, involving chemically interesting molecular species, in regimes from nanoKelvin to Kelvin temperatures. Examples of such molecules are those containing hydrogen, oxygen, carbon, or nitrogen. Research areas of particular interest include, but are not limited to: (1) state-selective study of molecular collisions and reactions, including state-resolved study of reaction products; (2) cold-molecule-based spectroscopy at unprecedented energy resolution; (3) the role of strong correlation and collective effects in quantum chemistry; (4) mixed species, e.g., free radicals, molecular ions, and Rydberg molecules; (5) collision studies of large molecules (>10 atoms), including small biological molecules.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2M per year in the research supported by this initiative. Proposals submitted under this initiative should support small teams of 2-4 investigators with awards of about \$500K per year for 3 years, or individual investigators with smaller awards. International collaborations are eligible for consideration.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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4. Fundamental Studies of Glass and Ceramics for High Average Power Lasers and Other Applications

Background: Glass and ceramic materials have made great technological advances, but there remain applications for them that are difficult or impossible without fundamental material studies, as described below. High average (and peak) power lasers, based on cladding pumped fiber lasers and arrays or ceramic slabs or thin disk lasers are examples.

This BRI has two main focuses. First is addressing fundamental materials understanding limiting power scaling; photo-darkening of glass fiber cores and the fabrication of robust spatial mode-control elements. Thermal effects, finite pump brightness, inadequate doping concentrations, non-linear effects and damage threshold limit the scalability of a single aperture fiber laser and interaction of the intrinsic physical properties create hard limits on the output power of broadband fiber.

The second focus of this topic is to place the science of polycrystalline laser host materials on a firmer basis and provide an effective path toward development of 100 kW and much higher power solid-state lasers. This BRI will investigate new specific scientific pathways to materials systems which could provide novel, thermally robust laser gain materials and thus revolutionize laser gain media, especially in improving the optical-to-optical efficiency of diffraction-limited laser systems. This will require the development of low optical loss ceramic materials and photonic like structures from polycrystalline laser host materials that parallel those found in high power fiber systems and diffusion-bonded edge-clad slab systems. The *challenge* is to build a bridge of knowledge between theoretical models of microstructure and experimental measurements. While current experimental investigations are consumed with investigating the scattering from pores and grain boundaries, our understanding of the fundamental nature of dopant interactions with defects in polycrystalline laser ceramics has been almost non-existent. It is the intent of this BRI to apply experimental methods, to understand new glass and ceramic compositions and structures, ones not normally found in the materials community, including a variety of linear and nonlinear spectroscopic techniques.

Objective(s): The first objective is to link the effective properties to relevant local fields of short range order of glass structure for fibers and lattice structure of polycrystalline ceramics. The approach is related to the design paradigm of defects through atomic scale modeling that is integrated from the bottom up. This objective requires design of weighted correlation functions that statistically exemplify the structure and demonstrate clear scientific pathways to create new glass compositions and new polycrystalline materials with tailorable laser properties. In both material systems, glass and polycrystalline ceramics, the plan is simply; “go back to the basics”; (a) interrogate local order of the glass structure and (b) understand lattice dynamics of polycrystalline materials in the context of super saturation. The second but equally important objective of this BRI is in the area of integration of concurrent research concentration areas; soft chemistry principles for powder processing, linking powder and processing properties, and the validation of atomic scale modeling by pertinent experimental tools of the materials science and laser science community.

Research Concentration Areas:

Super saturation in glass structures: Realization of the full potential of glass for high power laser applications requires tailoring materials at the atomic level. In the absence of periodicity the vibrations of disordered systems cannot be calculated analytically. The short range order for different glass compositions needs to be revisited to quantify the elastic continuum limit of different glass compositions to quantify the phonon interactions with the disordered scatterers and with each other. The disordered state of different glass compositions needs to be investigated to quantify softening characteristics with changing disorder, and to address the principal factors inhibiting the development of fiber lasers to higher continuous and pulsed powers. The mechanism of clustering (i.e., Er^{3+} in a silica host) must first be found, followed by a search for various means of mitigation to enhance the solubility limits of dopant additions. The determination of effective properties of the glassy state from the knowledge of the microstructure at multiple length scales will provide the link between apparently dissimilar physical properties of constituent atoms of the amorphous structure. At the root of this interaction with dopants and glass structure is the understanding of complex thermodynamic and

molecular dynamic phenomena interacting together on different timescales to define the supersaturated state.

Super saturation of lattice structure: The effect of competing property demands on highly doped polycrystalline structures require an understanding of cross-property relations and lattice optimizations, which need to take into account (1) dopant partitioning between grain boundaries and grain interior, (2) the quantitative correlation between grain boundaries and physical properties, (3) effect of dislocations, (4) portioning and precipitation of dopants in preferential planes, (5) the interaction of dopants and dopant clusters with point defects of cations, anion vacancies, traps and many more structure related defects. The ultimate aim is to elucidate elastic softening of a lattice containing a critical amount of dopants, which could lead to an order disorder transition with further supersaturation. Specific interests in this regard are the conditions to minimize point defects and thus achieve maximum thermal conductivity. In addition to inelastic neutron scattering experiments to analyze the changes in dynamic level, it is also envisioned utilizing electronic density functional theory, to solve the Kohn-Sham equations with the Perdew-Burke-Ernzerhof parameterization of the generalized gradient approximation for the electron exchange correlation potential. These atomic scale simulations should be augmented by continuum scale models (i.e., phase field theory) and validated through high resolution electron optic techniques (high resolution transmission electron microscopy), confocal laser scanning microscopy, nonlinear spectroscopic analysis, including LIBS (laser induced breakdown spectroscopy), and defect composition analysis through concurrent use of electron paramagnetic resonance (EPR), positron annihilation spectroscopy, atomic probe tomography, thermo-luminescence and electron spectroscopy for chemical analysis (ESCA), secondary ion mass spectroscopy (SIMS) and possibly electron microprobes. The predictive capability of the interfacial energy due to specific dopant additions, i.e., reduction of interfacial energy due to specific dopant segregation in the aforementioned defects, and the ability to incorporate the breaking and forming of bonds, provide the capability to estimate local transport properties and correlate with laser properties. The great untapped potential for laser media is Calcium Fluoride (CaF_2) and related compounds, a potential game changer. Many aspects of this class of materials are still not well understood. In the absence of theoretical studies, the nature of the carrier field, its extent and impact on the propagation and lifetime are not well understood and require investigative approaches that are similar to the aforementioned polycrystalline ceramics.

The research concentration areas should include but not limited to soft chemistry, including sol-gel, hydrothermal method, spray pyrolysis, and co-precipitation, to synthesize micrometer and nanometer particles. This research concentration area takes into account deflocculating and stabilization of cubic and non-cubic particles with the slurries which can manipulate the rough electrostatic, steric, or electrosteric stabilization mechanism, as well as magnetic alignment of particles with an anisotropic magnetic susceptibility. To illustrate the fundamental challenge for structure optimization, one must consider the link between effective parameters, especially the incorporation of actual environmental conditions during processing and use conditions within the modeling and the ability to garner thermodynamic and defect energy.

Resources:

Subject to the availability of funds, AFOSR anticipates investing up to \$2M/yr in research to support this initiative. Efforts from collaborative, multi-investigator teams are highly

encouraged. Prior to submitting a basic research proposal, interested parties should contact the AFOSR Program Officers below to discuss the proposed research project.

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5. *In-situ* Dynamic Mesoscale Measurements of Reacting Energetic Materials

Background: Initiation of detonation in energetic materials is inherently multi-scale, both in time and length. Mechanically-induced initiation processes depend on local defects, which result in stress concentrations and subsequent local temperature rise. If this temperature rise, or hot spot, is of sufficient size and temperature, chemical reactions are initiated and propagated in the energetic material, ultimately resulting in detonation. Several microstructural features have been attributed to hot spot formation including collapse of pores both in the explosive crystal and in the polymer binder, crystal-crystal interfaces resulting from cracks or mixing, and dislocations and shear bands within the crystals themselves.

Typically, experiments have been conducted on energetic materials at the continuum scale, traditionally with results that only provide a binary go – no-go answer. The effects of microstructure are inferred from comparisons of pre-test microstructures with these binary results. Similarly, traditional models for these materials are continuum scale with empirical or mechanistic descriptions of initiation and reaction propagation. Recently, advancements in mesoscale models and simulations have been used to capture the statistical variations in hot spot formation, revealing the effects of pores between grains in granular energetic composites and interactions between grains and polymeric binders. However, these mesoscale models capture only the behavior of the material up to the point of initiation resulting in a statistical description of critical hot spots. The local chemistry is not considered within these models, but plays a crucial role in the detonation dynamics.

Objective: The objective of this BRI is to experimentally characterize the mesoscale physics and chemistry of energetic materials to understand the role of stress concentrations, i.e. hot spots, in the initiation of energetic materials and the subsequent propagation of reaction. These research projects will develop experimental techniques and related modeling and simulation efforts to understand (1) the characteristic length scale for hot spot formation; (2) the dependence of hot spot size and temperature on mesostructure; and (3) the effect of local chemistry and interfacial interactions.

Research Concentration Areas: This program will explore:

- 1) Innovative fast diagnostics capable of characterizing critical mesoscale initiation chemistry and physics for shock and non-shock, high strain rate mechanical loading of energetic materials;
- 2) The initiation response of the energetic material, particularly hot spot formation, as a function of initial state, which may be a function of processing, mechanical damage, and/or thermal cycling;
- 3) Mesoscale simulation advancement through the incorporation of chemistry and interface dynamics capturing the complex interactions between mechanics and reaction;

4) Continuum ignition and growth models, informed by the mesoscale results to include more complex chemistry and materials.

This research integrates multiple disciplines including materials science, chemistry, shock physics, and energetic materials.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2M/year in the research supported by this initiative. Proposals submitted under this initiative should support teams of typically 2-4 investigators with awards ranging from \$500K - \$750K/year for three years. International participation in these teams is welcome.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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6. Molecular Electronics Enabled Control of Cellular Systems (Cyborgcell)

Background: Cellular signaling -- the intracellular and intercellular communication of information -- is the basis for the activities and actions of cellular systems. Therefore, modulating the pathways and networks of biological signaling provides a means for controlling cellular behavior. Being able to control and modulate the response and behavior of living cells with external stimuli is a desirable feature that can be useful in future Air Force applications with biological systems. To achieve this modulation, many recent studies focus on understanding and characterizing cellular communication mechanisms. To this end, scientists and engineers are seeking new concepts and tools that can achieve simultaneous sensing and stimulation of subcellular components with high spatiotemporal resolutions.

Recent developments by various groups have shown that nanoelectronics and organic electronics can efficiently stimulate and detect cellular activities. For example, synthetic conducting polymers such as PEDOT:PSS and P3HT:PCBM have been successfully used to stimulate neurons, while sophisticated ion bipolar junction transistors can deliver analytes whilst maintaining long term neuronal function. Nanoscale semiconductor materials and devices have also been used extensively to interrogate biological systems, e.g., guiding light into localized regions of single cells recording intracellular action potentials from single cardiomyocytes and field potentials from acute brain slices. Significantly, nanoscale field effect transistors and p-n diodes have been placed inside single cells and synthetic tissues, and used to probe the cellular activities electrically. With these scientific and technical advances, we are now in a position to integrate semiconductor electronics and optoelectronics with biological systems at the molecular and organelle levels and learn to control its behavior to achieve desirable effects, such as specific protein expression and directed synthetic biology.

This initiative seeks to integrate the latest advances in understanding intracellular communication and organic molecular electronics and nanoelectronics to form a living cell with artificially inserted electronic circuits which can be controlled through untethered external stimuli. Single molecule elements can be covalently bonded to form larger molecules that

function as a rudimentary electronic circuit that can be inserted into a living cell. Such a cell, a cyborgcell, may be controlled via external stimuli to achieve desirable function or behavior. Most past research in controlling cellular behavior has been at the extracellular level. This initiative is to push the research with a focus at intracellular level control.

Objective: To integrate organic nano-electronics and cellular biology to create an artificial cell which contains intracellular electronic components. The function and/or behavior of this self-contained living cell, a cyborgcell, will be manipulated and controlled by external stimuli.

Research Concentration Area(s): (1) Identify and investigate sets of rudimentary electronic functions and single cells whose electronic functionalities are compatible and capable of influencing the communication or control pathways of the cell. (2) Design and synthesis of rudimentary nano-electronic circuits that can perform basic electronic functions upon external stimuli such as electric, magnetic and optical fields. These circuits should be bio-compatible and of size and scale suitable for insertion into a living cell and its functionalities relevant to influencing of cell behavior pathways. (3) Develop methodologies to integrate the synthesized electronic components into individual living cell without undue damage to the cell or the electronic circuits. (4) Devise approaches if necessary to provide protection to the inserted electronic circuits from attacks by the cell's immune system. (5) Characterize the functionalities of the electronic components via external stimuli prior to and post insertion into the cell and understand the effect of the intracellular environment on the functionalities of the nano-electronics. (6) Demonstrate that the function and/or behavior can be manipulated and controlled by external stimuli.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2m/yr in the research supported by this initiative. Proposals submitted under this initiative should support MURI-like teams of typically 3-5 investigators with awards up to \$1M/yr for 3-5 years. Please note that this initiative emphasizes research that bridges the boundaries across multiple AFOSR portfolios. International participation is encouraged.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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7. Muscular-Skeletal System Inspired Morphing Air Vehicles Using Active Materials

Background: The ease and skill with which birds fly and soar over the ground and seas and survive in a variety of environments are in sharp contrast to the operations of typical aircraft where the wings are held in a fixed position for the duration of a flight. With variable and movable wings, birds can deal with the different conditions encountered during flight, thus reducing the power required to fly. It should be noted that the morphing of bird wings is enabled by muscular control over the skeleton and feathers, which are loosely connected and can

be folded over each other. Skeletal muscles arranged in criss-crossing layers down to the bones can contract and pull the anchored bones causing local movement. Each skeletal muscle consists of densely packed groups of myofibers and contains tiny sensors, known as neuromuscular spindles, which relay information to the brain about muscle length and tension. Muscles are arranged in pairs that act in opposition to one another. When a muscle contracts to produce movement, its opposite partner relaxes and is passively stretched. Recent research progress indicates that, in parallel with these examples in nature, it is possible to design and deploy (i) a mechanized form of active materials with kinematic elements which allow morphing mechanisms by altering their shape, functionality and mechanical properties on demand, and (ii) computational meta-materials (materials becoming computers and vice versa) which can sense and change their properties based on programmable logic. Such fundamental scientific breakthroughs will lead to a new class of bio-inspired multifunctional structures allowing pervasive morphing ability, autonomous capability and higher system efficiency for a variety of aircrafts and defense systems.

Objective: To provide the scientific basis for multifunctional design of “morphing” air vehicles capable of autonomously altering the geometry, surface area and mechanical properties of wings in response to the changes in operating conditions by mimicking “muscular-skeletal” system of birds and by deploying a new generation of “active” materials for structural reconfiguration.

Concentration Areas: Suggested research areas are as follows: (1) Theoretical and experimental understanding of how morphological and kinematic parameters of bird wings determine unsteady aeromechanics and flight dynamics; (2) Analysis and modeling of the interaction between air flow, compliance of morphing wing structures, locomotion of muscular tendons and skeletal frames in coordination and power efficiency for the nature versus engineered system; (3) Bio-inspired design of composite air vehicle, which can autonomously deform its wings like a bird by controlling the geometry, surface area and stiffness of skeletal frame with muscular structural tendons and morphing joints; (4) Predictive design and novel processing of active materials (e.g. shape memory, electro-active, dynamically reconfigurable, particle coupling in micro-vascular networks, reversible adhesion, etc.) into assemblies that reversibly modulate mechanical properties; (5) Structural integration of mechanized active materials in conjunction with computational meta-materials for sensing, communication, actuation and reconfiguration; (6) Development of networking capability to sense external stimuli (such as wind gusts or temperature changes) and provide feedback to the control system for morphing of the aircraft wings autonomously.

Resources: The amount of resources made available to this BAA will depend on the quality of proposals received and the availability of funds, but probably will not exceed \$2,000,000/year. The current initiative is intended to organize at least one multi-disciplinary research program as a focal point and a number of single PI grants in key sub-areas as supporting efforts. Multi-disciplinary teams of researchers are expected to display the skills needed to address the relevant research challenges necessary to meet the program goals. All proposals will describe cutting-edge efforts on basic scientific problems. The duration of the proposed effort will be a 3-year base period with 2-year option period to bring the total maximum term of each award to five years.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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8. Predictive Probabilistic Representation and Fusion Approaches for Resident Space Objects

Background: As the space domain becomes increasingly congested due to rampant global use of space and on-orbit collisions, there is a critical need to help better characterize this precarious, yet vital environment. The U.S. Air Force, as the leading government organization responsible for cataloging and tracking space objects, is challenged by the need to improve conjunction analysis methods and prediction capabilities. The task of tracking resident space objects (RSOs) in and of itself is already a challenging problem, but assimilating the tracking data into useful and actionable information is an even more perplexing problem that must also be addressed. Current space-tracking sensor detections are subject to finite resolution, noise, and false positives (clutter). Most orbits are propagated forward in time using simplifying assumptions that are not always valid. When an object is first detected there is a large ambiguity as to its orbit and characteristics (i.e. mass, orientation, size, material properties, etc.). Fundamental elements of estimation theory and the flow of information through and across a dynamically evolving, uncertain population must be accounted for in this problem. In addition, current attempts to automate the estimation process usually treat the stages of detection, identification, and tracking separately which incurs information loss and results in a suboptimal solution. An optimal solution should treat the detection, identification and tracking problem as a joint estimation problem which maximizes some information-theoretic cost. Thus, a proper formulation for space objects draws from a more fundamental physics paradigm where RSOs are represented as probability distributions within their state spaces.

Overall, there is a growing need for accurate estimation techniques to operate within the framework of a rapidly increasing volume of data. Valuable information is lost, when treating separately detection, characterization, tracking and, in some cases data association. Instead in this BRI we seek to explore novel and integrated approaches.

Objective(s): The goal of this initiative is to use multi-disciplinary, dynamic data-driven approaches to forge a new scientific basis that will enable the Air Force Research Laboratory (AFRL) to develop tools for solving the critical Air Force needs of: conjunction/collision predictions; realistic, quantifiable measures of space object ambiguity; and accurate and precise long-term 6+Degree-Of-Freedom trajectory propagations.

Research Concentration Area(s): The scope includes, but is not limited to, the following theoretical, experimental and modeling effort sub-areas: [a] information-theoretic sensor data fusion and RSO state/parameter inference; [b] taxonomy-aided Bayesian classification of RSOs;

[c] computationally efficient and accurate methods of RSO data association and orbital dynamical system prediction. The focus will be on investigations applying information-theoretic and information-fusion approaches. For improving predictive capabilities, dynamic data-driven modeling methods are sought, whereby executing models are updated with on-line data to improve modeling accuracy and efficiency, and in return the models selectively target what additional data need to be collected, then dynamically schedule and correlate such additional measurements collected on-line, and/or selectively include data that have been previously collected and are in archival storage. For addressing uncertainty, the development and generalization of theories for describing uncertain systems in high dimensions with strongly nonlinear dynamics and affected by uncertain physical models (i.e. the space environment) must be considered. Of particular interest are development and implementation of advanced space object identification and discrimination techniques based upon multiple hypothesis testing and multi-sensor/multi-target tracking theory. New approaches such as finite-set statistics are needed and there is a knowledge gap between advances in the field of applied mathematics and the specific needs within the space research community to derive algorithms within this framework. Mathematical techniques to develop novel, efficient algorithms that can be applied to orbital propagation and to quantifying the uncertainties and exploiting the information fusion opportunities are sought. In addition, a taxonomy clarifying the classes of RSOs will be considered, drawing on the classification methods of the biological sciences.

Resources: Subject to the availability of funds, AFOSR anticipates investing up to \$2M per year in the research supported by this initiative. Proposals submitted under this initiative should support awards ranging from \$60K to \$150K/year renewable for up to 3 years. Please note that this initiative emphasizes research that bridges the boundaries across multiple AFOSR portfolios including the international programs. Proposals must be submitted in accordance with the BAA instructions.

Researchers are highly encouraged to contact the Program Officer prior to developing full proposals to briefly discuss the current state-of-the-art, how the proposed effort would advance it, and the approximate yearly cost for a three year effort.

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g. Other Innovative Research Concepts:

Program Description: AFOSR is always looking for new basic 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.

Basic Research Objective(s): 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 U.S. Air Force 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 U.S. Air Force mission.

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h. Education and Outreach Programs

(Disclaimer: For reference only; Proposals **NOT** submitted under this BAA)

The Scientific and Technology Departments of AFOSR, Business Integration Department (RP), the International Office (IO), and three overseas detachments, AOARD and EOARD and SOARD, 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.

- 1) Air Force Visiting Scientist Program
- 2) Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE)
- 3) Engineer and Scientist Exchange Program (ESEP)
- 4) National Defense Science and Engineering Graduate (NDSEG) Fellowship Program
- 5) United States Air Force/National Research Council Resident Research Associateship (NRC/RRA) Program
- 6) United States Air Force-Summer Faculty Fellowship Program (SFFP)
- 7) Window on Science (WOS) Program
- 8) Windows on the World (WOW) Program

Research areas are described in detail in the Sub areas below:

1. Air Force Visiting Scientist Program

Program Description: The AF Visiting Scientist Program provides outstanding U.S. Air Force scientists and engineers the opportunity to conduct full-time, "hands-on" research-related work in a leading United States University or industry laboratory for a period of up to 179 days on a temporary duty (TDY) 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 U.S. Air Force scientist or engineer, at least at the GS-13/DR-II 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 five 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 Research Laboratory site or at AFOSR and to provide feedback for purposes of program assessment. Upon completion of the assignment the researcher returns to his/her Air Force Research Laboratory site. Additional information is available at <http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9331> under VSP Qualification and Eligibility Requirements.

Point of Contact (POC):

Mrs. Leslie Peasant, AFOSR/IO, (703) 696-7316

DSN 426-7316, FAX: 703) 696-8450

E-mail: leslie.peasant@us.af.mil

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

Program Description: 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.

Basic Research Objectives: 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. The majority of these funds are being used to support existing research sites and commitments. Based on the existing commitments, in

FY14 the maximum number of new research projects/areas to be funded will be up to five. 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>.

Point of Contact (POC):

Mr. Neville Thompson, AFOSR/CL, (703) 588-1779

DSN 425-1779, FAX: (703) 696-7364

E-mail: neville.thompson@us.af.mil

3. Engineer and Scientist Exchange Program (ESEP)

Program Description: 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, the Czech Republic, Chile, France, Germany, Israel, Italy, Japan, Norway, Poland, Republic of Korea, Singapore, Spain, The Netherlands, and the United Kingdom.

Basic Research Objectives: 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 U.S. Air Force 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.

U.S. 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/ION is responsible for managing placement of all ESEP exchanges within the U.S. Air Force, and is the "one face to the customer" for all U.S. Air Force ESEP actions. SAF/IAPQ (Armaments Cooperation Division, Deputy Under Secretary of the Air Force, International Affairs), the executive agent, provides policy guidance. The Asian, European and Southern Offices of Aerospace Research and Development (AOARD/EOARD/SOARD) are AFOSR field offices located in Tokyo, London and Santiago. These offices act as overseas program liaison offices for US ESEP personnel working in Asia, Europe and South America.

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

SAF/IAPQ issues a separate call for applicants with application instructions. Contact the following Point of Contact for more information.

Point of Contact (POC):

Mr. Phil Gibber, AFOSR/ION, (703) 696-7323

DSN 426-7323 FAX: (703) 696-8450

E-mail: philip.gibber.1@us.af.mil

4. National Defense Science and Engineering Graduate (NDSEG) Fellowship Program

Program Description: 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 2014; the graduate program must lead toward 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 2014. 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 FY2014 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 NW, Suite 600, Washington, DC 20036
Phone: (202) 331-3516; Fax: (202) 265-8504
E-mail: ndseg@asee.org
<http://www.asee.org/ndseg>

Point of Contact (POC):
Mr. Neville Thompson, AFOSR/CL, (703) 588-1779
DSN 425-1779, FAX: (703) 696-7364
E-mail: neville.thompson@us.af.mil

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

Program Description: The NRC/RRA Program offers postdoctoral and senior scientists and engineers opportunities to perform research at sponsoring U.S. Air Force laboratory sites.

Basic Research Objectives: 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 U.S. 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 U.S. citizens and permanent residents 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. 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 U.S. 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 (Keck 568)
National Research Council
500 Fifth St, NW, Washington DC 20001
Phone: (202) 334-2760
E-mail: rap@nas.edu
<http://www.national-academies.org/rap>

Point of Contact (POC):
Mr. Neville Thompson, AFOSR/CL, (703) 588-1779
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E-mail: neville.thompson@us.af.mil

6. United States Air Force-Summer Faculty Fellowship Program (SFFP)

Program Description: The SFFP offers fellowships to university faculty to conduct research at one of the U.S. Air Force research facilities in the summer.

Basic Research Objectives: 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 Departments and other U.S. Air Force research facilities; (2) elevate the awareness in the U.S. academic community of U.S. 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 Departments and other U.S. Air Force research facilities.

SFFP fellows conduct research in collaboration with U.S. Air Force researchers for a continuous summer period of eight to twelve weeks at the Technical Departments of the U.S. Air Force Research Laboratory, the US Air Force Academy, U.S. Air Force Institute of Technology, and Air Force Test Center. 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 U.S. 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. Starting in Fiscal Year 2010, selected fellows may bring a graduate student with them to assist in research on their assignment.

Point of Contact (POC):

Mr. Neville Thompson, AFOSR/CL, (703) 588-1779

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7. Window on Science (WOS) Program

Program Description: 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 U.S. Air Force scientists and engineers at U.S. AIR FORCE sites typically within the United States, 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 U.S. Air Force interests, WOS visitors may also combine visits to U.S. Air Force R&D organizations with visits to Army, Navy, other government, university, or industrial facilities. AFOSR's 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. The Asian Office of Aerospace Research and Development (AOARD), Tokyo, Japan manages this program for the remainder of Asia and the Pacific Rim. The Southern Office of Aerospace Research and Development (SOARD), located in Santiago, Chile manages the WOS program for the Americas. Participants in the WOS program will be foreign researchers identified as subject matter experts by AFRL Program Officers, and whose visit benefits U.S. 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 U.S. 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/AOARD/SOARD:

<http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=8971>

8. Windows on the World (WOW) Program

Program Description: The Windows on the World program provides outstanding U.S. 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 U.S. Air Force activity. The host laboratory provides facilities, resources, and a letter of invitation. Typically the researcher is an U.S. Air Force scientist or engineer, at least at the GS-13/DR-II 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 ten 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 Department 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 AFOSR and/or the Air Force Research Laboratory site and provide feedback for purposes of program assessment. Lead-time to set up a "Windows" visit is approximately four months. More detailed information is contained in the AFOSR Brochure, "Windows on the World" located online at:

<http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=9383>.

Point of Contact (POC):

Mr. Phil Gibber, AFOSR/ION, (703) 696-7323

DSN 426-7323 FAX: (703) 696-8450

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i. Special Programs:

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

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

Program Description: The DoD has been providing grants for research and educational equipment at Historically Black Colleges and Universities and Minority Serving Institutions (HBCU/MI). The DoD encourages basic research proposals from the HBCU/MI community in full and open competition with all offerors.

Basic Research Objectives:

AFOSR HBCU/MI program consists of two components:

(1) AFOSR Core Research: Proposals are encouraged from HBCU/MIs, which are accredited U.S. postsecondary institutions that have been designated as MSIs by the Department of Education. However, no funds are specifically allocated for HBCU/MI participation.

Proposals from HBCU/MIs are reviewed by AFOSR Program Officers to broaden participation among diverse individuals and institutions while reaching out to groups that have been underrepresented. Submissions should relate to the research interests of AFOSR identified in Section I of this Broad Agency Announcement (BAA) or to other basic research concepts. In addition to single investigator basic research, collaborative research proposals are also of interest where the HBCU/MI is the lead institution for the effort.

(2) DoD Infrastructure Support Program: This program is administered by the Army Research Office (ARO), in collaboration with the AFOSR. Schools interested in this program should look for the Broad Agency Announcement that is usually published in the fall of each year in the ARO webpage. The BAA is linked through the AFOSR Web site at <http://www.wpafb.af.mil/AFRL/afosr/>, under "Funding Opportunities", "Special Programs", click on the HBCU/MI link and download the announcement.

Point of Contact (POC):

Mr. Ed Lee, AFOSR/RTA, (703) 696-7318

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2. Small Business Technology Transfer Program (STTR)

Program Description: 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.

Basic Research Objectives: The primary objective of the U.S. Air Force STTR program is to involve small businesses in Air Force-relevant defense research, and enable them to commercialize their innovative technologies for the advancement of U.S. economic competitiveness.

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 \$150,000 for a period not to exceed nine months; and Phase II projects are two-year efforts for amounts up to \$1,000,000. More information regarding the U.S. Air Force STTR can be found at:

<http://www.acq.osd.mil/osbp/sbir/solicitations/index.shtml>

Point of Contact (POC):

Mr. Raheem Lawal, AFOSR/RTE, (703) 696-7313

DSN 696-7313, FAX (703) 696-8450

E-mail: raheem.lawal@us.af.mil

3. Young Investigator Research Program (YIP)

Program Description: The U.S. Air Force YIP supports scientists and engineers who have received Ph.D. or equivalent degrees in the last five years and show exceptional ability and promise for conducting basic research.

Basic Research Objectives: 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 U.S. Air Force mission and related challenges in science and engineering.

Individual awards will be made to U.S. institutions of higher education, industrial laboratories or non-profit research organizations where the principal investigator is a U.S. citizen, national or permanent resident; employed on a full-time basis and holds a regular position. Researchers working at the Federally Funded Research and Development Centers and DoD Laboratories will not be considered for the YIP competition. Each award will be funded at the \$120K level for three years. Exceptional proposals will be considered individually for higher funding levels and longer duration. A BAA specific to this program will be announced once a year and, while open, will be posted to Grants.gov (www.grants.gov) and FedBizOpps (www.fbo.gov). The YIP BAA will contain specific information about YIP proposal preparation and submission. General

information about the Young Investigator Program may be found on the AFOSR website. The AFOSR YIP group (<http://www.linkedin.com/groups/AFOSR-Young-Investigator-Research-Program-5052168>) and the AFOSR YIP twitter account (@AFOSRYIP, <http://twitter.com/AFOSRYIP>) provide forums for announcements, current news, and other information regarding the program and its participants.

Point of Contact (POC):

Ms. Ellen D. Montgomery, AFOSR/RTB, (703) 588-8527

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Email: ellen.montgomery@us.af.mil

j. 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 "Funding Opportunities;" "University Research Initiative (URI) Programs."

1. Defense University Research Instrumentation Program (DURIP)

Program Description: 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 by U.S. institutions of higher education to augment current or develop new research capabilities to support research in technical areas of interest to the DoD.

Basic Research Objectives: DURIP is open only to U.S. institutions of higher education, with degree granting programs in science, math, and/or engineering. Proposing institutions should be seeking to purchase instrumentation in support of research areas of interest to the DoD, including areas of research supported by the administering agencies. Proposals to purchase instrumentation may request \$50,000 to \$1,500,000. Awards are typically one year in length. Details on the proposal submission process and further specifics on the DURIP can be found in the most recent DURIP announcement at <http://www.wpafb.af.mil/AFRL/afosr/>, under "Funding Opportunities;" "University Research Initiative (URI) Programs;" "Defense University Research Instrumentation Program (DURIP)."

Point of Contact (POC):

Ms. Katie Wisecarver, AFOSR/RTD, (703) 696-9544

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E-mail: Katie.Wisecarver@us.af.mil

2. Presidential Early Career Award in Science and Engineering (PECASE)

Program Description: The National Science and Technology Council (NSTC) 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.

Basic Research Objectives: 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 U.S. 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 AFOSR or former National Defense Science and Engineering Graduate (NDSEG) fellowship recipients. Candidates must hold tenure-track positions at U.S. universities. Individuals can not apply to the PECASE program but must be nominated by an AFOSR Program Officer and have a proposal that addresses U.S. Air Force research interests as described in the current AFOSR Broad Agency Announcement (BAA). Furthermore, the White House Office of Science and Technology Policy will make the final selection and announcement of the awardees.

Point of Contact (POC):

Ms. Ellen D. Montgomery, AFOSR/RTB, (703) 588-8527
DSN 425-8527, FAX: (703) 696-8450
Email: ellen.montgomery@us.af.mil

k. Conferences and Workshops:

The Air Force supports conferences and workshops (as defined in the DoD Travel Regulations) in special areas of science that bring experts together to discuss recent research or educational findings or to expose other researchers or advanced graduate students to new research and educational techniques.

Conferences and workshops constitute key forums for research and technology interchange. AFOSR's financial support through appropriate financing vehicles for conferences and workshops is dependent on the availability of funds, Program Officer's discretion, and certain other restrictions including:

- AFOSR support for a workshop or conference is not to be considered as an endorsement of any 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 U.S. 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 U.S. Air Force basic research program. Proposals for conference or workshop support are encouraged to be submitted a minimum of six months prior to the date of the conference. Proposals should include the following:

Technical Information:

- 1) Summary indicating the objective(s) of the conference/workshop
- 2) Topic(s) to be covered and how they are relevant to AFOSR's mission of managing the U.S. Air Force basic research program
- 3) Title, location, and date(s) of the conference/workshop
- 4) Explanation of how the conference/workshop will relate to the research interests of AFOSR identified in Section I of the Broad Agency Announcement (BAA)
- 5) Chairperson or principal investigator and his/her biographical information
- 6) List of proposed participants and method (or copies) of announcement or invitation
- 7) A note on whether foreign nationals will be present

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

- 1) Total project costs by major cost elements
- 2) Anticipated sources of conference/workshop income and amount from each source
- 3) Proposals should break down how AFOSR funds will be spent in sufficient detail for AFOSR personnel to determine whether costs are allowable. See Part 200 of

the Code of Federal Regulations (CFR) Section 200.420 – 200.475 for a listing of allowable and unallowable costs;

<http://www.ecfr.gov/cgi-bin/text-id?SID=36766b4d82ebca47caae047cb4606343&node=2:1.1.2.1.1&rgn=div5>

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).
- Overall realism and reasonableness of cost including proposed cost sharing when applicable and availability of funds.

Eligibility

Notwithstanding the above, the Department of Defense (DOD) has imposed certain restrictions on the Air Force's co-sponsorship of scientific and technical conferences and workshops. Specifically, DOD Instruction 5410.20 prohibits co-sponsorship of conferences and workshops with commercial concerns. Scientific, technical, or professional organizations which qualify for tax exemption under the provision of 26 U.S.C. Sec. 501(c)(3) may receive conference and workshop grants.

Applicants for support of conferences or workshops must be registered as “tax exempt” in the System for Award Management (SAM.gov) or follow the instructions at <http://www.irs.gov/uac/Form-W-8EXP,-Certificate-of-Foreign-Government-or-Other-Foreign-Organization-for-United-States-Tax-Withholding>.

Participant Support

Funds provided cannot be used for payment to any federal government employee for support, subsistence, or services in connection with the proposed conference or workshop.

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

II. Award Information

1. In Fiscal Year 2013, AFOSR managed funding support for approximately 1560 grants, cooperative agreements, and contracts to about 460 academic institutions, non-profit organizations and industrial firms. This included grants, cooperative agreements and contracts to academic institutions, non-profit organizations and industry. About \$300M is anticipated to be available for support of actions awarded through this BAA process; subject to availability of funds. Research proposals in the range of \$200-400K per year are encouraged. Awards 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 (but see additional eligibility requirements for conferences and workshops under Section I. k.). AFOSR particularly encourages proposals from small businesses; 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.

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 proposals that do not contain proprietary information. AFOSR will make every effort to protect the confidentiality of any proprietary information submitted as long as it is properly marked. 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 –Non-government evaluators and support contractors retained by AFOSR. See Section V). **It is the offerors’ responsibility to notify AFOSR of proposals containing proprietary information and to identify the relevant portions of their proposals that require protection. The entire proposal (or portions thereof) without protective markings or otherwise identified as requiring protection will be considered to be furnished voluntarily to AFOSR without restriction and will be treated as such for all purposes.** Since the Government

anticipates the award of 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. Prior to proposal submission.

Applicants are encouraged to contact the Program Officer for the subject area to discuss the proposed research effort, particularly the current state of related research, the potential of the effort to advance the state of the art, and anticipated budget. The Program Officer may ask for additional information at that time.

However, in your conversations with a Government official, be aware that only warranted contracting and grants officers are authorized to commit the Government.

b. Proposals. The proposal may be submitted either electronically through Grants.gov or in hard copy form, but not both. Proposers submitting in hard copy format are strongly encouraged to follow-up by email with the AFOSR program officer to validate that the proposal has been received. 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

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 Officer)
- 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 System for Award Management (SAM), 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 SAM registration process.) Go to <http://www.grants.gov/web/grants/applicants/organization-registration.html> and use the Grants.gov Organization Registration Checklist 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 ensure you have the required version of Adobe Reader installed or to download a free version of the software, visit the following web site: <http://www.grants.gov/web/grants/support/technical-support/software/adobe-reader-compatibility.html>. 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” under “Applicants,” and then follow the instructions. Or in the Grants.gov search function, enter the funding opportunity number for this announcement (BAA-AFOSR-2014-0001). You can also search for the CFDA Number 12.800, Air Force Defense Research Sciences Program. On the “View Grant Opportunity” page, click on the “Application Package” tab 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 Department specific to your area of interest to download the instructions and application.

If you are unsure which Department and Program Officer 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. 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://www.grants.gov/web/grants/support/technical-support/software/pdf-conversion-software.html>.

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

AFOSR (Attn: Name of Program Officer)
Air Force Office of Scientific Research
875 North Randolph Street, Suite 325 Room 3112
Arlington VA 22203-1768

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

AFOSR (Attn: Dr. Van Blackwood)
Air Force Office of Scientific Research
875 North Randolph Street, Suite 325 Room 3112
Arlington VA 22203-1768

Applicants should send hard copy submissions through a delivery method that allows the sender to confirm receipt. Additionally, the applicant should contact the Program Officer to confirm receipt. Proposals should not be submitted by email.

(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 field's will self populate based on the BAA selected. Please fill out the SF 424 (R&R) 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 16:** Choose 'No'. Check 'Program is Not Covered By Executive Order 12372'.

- **Field 17:** Select "I Agree" to:

Provide the certification regarding lobbying that is required by law (13 USC 1352, as implemented by the DoD at 32 CFR Part 28). The full text of this certification may be found at <http://www.wpafb.af.mil/shared/media/document/AFD-070817-127.pdf> or a copy will be provided upon request.

Certify that the statements in the proposal and the associated representations on tax delinquency and felony convictions are true, complete and accurate to the best of your knowledge.

- **Field 18:** Attach the representations on tax delinquency and felony convictions. Also attach the SF-LLL or other explanatory documentation if there is lobbying that must be disclosed under 13 USC 1352, as implemented by the DoD at 32 CFR Part 28.

- **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/web/grants/support/technical-support/software/pdf-conversion-software.html>.

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

(d) 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. Primes

should ensure that subrecipients' cost information reflects the same level of detail as the primes' cost information. The format should follow the Prime's submission as well. See section IV. 3. (i) R&R Budget Form for detail on submission of the Prime's budget information. 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.

(e) 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.

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

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

Human Subject Use- Each proposal must address prospective human subject or rDNA involvement by addressing Field 1 and 1a of the R&R Other Project Information Form. If selected for award, additional documentation in accordance with U.S. Air Force standards is required. All inquiries for proposals to AFOSR regarding human subjects or rDNA should go to the AFOSR Research Protections Officer, Stephanie Bruce at stephanie.bruce.2@us.af.mil.

Animal Use- Each proposal must address prospective animal subject involvement by addressing Field 2 and 2a of the R&R Other Project Information Form. If selected for award, additional documentation in accordance with U.S. Air Force standards is required. All inquiries for proposals to AFOSR regarding animal subjects should go to the AFOSR Research Protections Officer, Stephanie Bruce at stephanie.bruce.2@us.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 Officer. Most research efforts

funded by AFOSR will, however, qualify for a categorical exclusion from the need to prepare an EIS. U.S. 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.

Data Management Plan- Applicants are required to have a Data Management Plan and must state this in the proposal. OMB guidance regarding Data Management Plans is forthcoming and shall be addressed in the Terms and Conditions of an award. At this time, all proposals must include a supplementary document of no more than two pages labeled “Data Management Plan”. The plan should address data management issues such as:

- 1) the types of data, samples, physical collections, software, curriculum materials, and other materials to be produced in the course of the project;
- 2) the standards to be used for data and metadata format and content (where existing standards are absent or deemed inadequate, this should be documented along with any proposed solutions or remedies);
- 3) policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
- 4) policies and provisions for re-use, re-distribution, and the production of derivatives; and
- 5) plans for archiving data, samples, and other research products, and for preservation of access to them.

Attach the Data Management Plan to the R&R Other Project Information form in field 12, Other Attachments.

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 Officer’s name and Department who should receive the proposal for consideration and evaluation. Attach the Abstract to the R&R Other Project Information form in field 7.

(h) 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 8.

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 Officers will facilitate the establishment of accounts awarded.

(i) 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. (See Title 2 Code of Federal Regulations (CFR) Sections 200.420 – 200.475 for a listing of allowable and unallowable costs under Federal awards;

<http://www.ecfr.gov/cgi-bin/text-idx?SID=36766b4d82ebca47caae047cb4606343&node=2:1.1.2.1.1&rgn=div5>

Applicants who enter a fee on Part J of the budget will not be eligible to receive a grant or cooperative agreement.

In addition to the Research and 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. For example, travel should be itemized (quantity of trips/personnel, destination, duration, and purpose). Materials, supplies and equipment should also be itemized with the basis for costs provided. List all material/equipment by type and kind with associated costs and indicate if the costs are based on vendor quotes, data and/or engineering estimates; provide copies of vendor quotes and/or catalog pricing data. Attach the budget justification to Section K of the R&R Budget form.

If a current rate agreement is used to propose indirect cost rates and/or fringe benefit rates, attach a copy of the agreement to Section K of the R&R Budget form as well.

(j) Certifications –

Representations on tax delinquency and felony convictions Check either “is” or “is not” for each of the two representations, as appropriate for the proposing institution, and attach the representations page to field 18 of the SF-424. The representations page is provided with the application materials for the funding opportunity that are available for download at grants.gov.

SF-LLL Form “Disclosure Form to Report Lobbying” -- If your organization has lobbying activities that you are required to disclose under 31 USC 1352, as implemented by the DoD at 32 CFR part 28, you also must complete and attach the SF-LLL form in the downloaded Adobe forms package at Grants.gov.

Online Representations and Certifications If it is determined that 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 in the System for Award Management (SAM) at <http://www.sam.gov>. The representations and certifications shall be submitted to SAM 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 SAM. In addition to the SAM representations and certifications, prospective contractors shall complete the AFOSR Contract Certification which will be supplied upon request.

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 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 should contact the Program Officer to verify receipt.

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. **However, some topics have specific due date**

restrictions; see topic descriptions above for these restrictions. For additional information regarding the BAA process please refer to the AFRL BAA Guide for Industry at <http://www.wpafb.af.mil/shared/media/document/AFD-120614-075.pdf>.

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 U.S. Air Force encounters in developing and maintaining a superior U.S. Air Force; lowering the cost and improving the performance, maintainability, and supportability of U.S. 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 (41 USC 253), 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 Officers at EOARD/AOARD and the appropriate AFRL Technology Departments, other military services, DoD agencies, civilian agencies and non-Government sources. Non-Government sources can include academia, nonprofit institutions, and support contractor personnel. Non-Government evaluators are authorized access only to those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. Government and non-Government evaluators are also required to sign nondisclosure agreements which prohibit them from disclosing proprietary information submitted by applicants in a proposal. **However as previously stated in Section IV para 2, AFOSR is seeking proposals that do not contain proprietary information. If proprietary information is submitted it is the offerors responsibility to mark the relevant portions of any submissions as specified in Section IV paragraph 2.**

Employees of commercial firms under contract to the Government may be used to administratively process proposals and may gain access to proprietary information contained in proposals and/or post award documentation. These support contracts include nondisclosure agreements prohibiting their contractor employees from disclosing any information submitted by applicants.

Section I categories h through j provide information about AFOSR programs and awards that are not evaluated under this BAA. For information on submitting proposals for the Education and Outreach, Special Programs and University Research Initiative (URI) Programs; see the hyperlinks in each section. Proposals submitted for Special Programs listed in Section I category h through j shall be evaluated under criteria as specified in their description. Proposals submitted for Conference Support and Workshops listed in Section I shall be evaluated under criteria as specified in its 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; and
2. Potential relationship of the proposed research and development to Department of Defense missions.

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 capabilities integral to achieving U.S. Air Force objectives. This includes principal investigator's, team leader's, or key personnel's qualifications, related experience, facilities, or techniques or a combination of these factors integral to achieving U.S. Air Force objectives, and the potential risk of this effort to the U.S. Air Force.
3. Overall realism and reasonableness of proposed costs.

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

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 an email notification from AFOSR 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

Deliverables: Grants and cooperative agreements typically require annual and final performance reports, final financial reports, and final invention reports. Contracts typically require annual and final technical and invention reports.

Open Access: Effective Oct 1, 2014, copies of all publications resulting from research supported by AFOSR are required to be submitted electronically to the AFOSR Program Officer.

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

3. Additional information for offerors seeking contract awards

a. 252.227-7017 Identification and Assertion of Use, Release, or Disclosure Restrictions.

As prescribed in [227.7103-3](#)(b), [227.7104](#)(e)(2), or [227.7203-3](#)(a), use the following provision:

IDENTIFICATION AND ASSERTION OF USE, RELEASE, OR DISCLOSURE RESTRICTIONS (JAN 2011)

(a) The terms used in this provision are defined in following clause or clauses contained in this solicitation—

(1) If a successful offeror will be required to deliver technical data, the Rights in Technical Data--Noncommercial Items clause, or, if this solicitation contemplates a contract under the Small Business Innovation Research Program, the Rights in Noncommercial Technical Data and Computer Software--Small Business Innovation Research (SBIR) Program clause.

(2) If a successful offeror will not be required to deliver technical data, the Rights in Noncommercial Computer Software and Noncommercial Computer Software Documentation clause, or, if this solicitation contemplates a contract under the Small Business Innovation Research Program, the Rights in Noncommercial Technical Data and Computer Software--Small Business Innovation Research (SBIR) Program clause.

(c) Offers submitted in response to this solicitation shall identify, to the extent known at the time an offer is submitted to the Government, the technical data or computer software that the Offeror, its subcontractors or suppliers, or potential subcontractors or suppliers, assert should be furnished to the Government with restrictions on use, release, or disclosure.

(d) The Offeror's assertions, including the assertions of its subcontractors or suppliers or potential subcontractors or suppliers, shall be submitted as an attachment to its offer in the following format, dated and signed by an official authorized to contractually obligate the Offeror:

Identification and Assertion of Restrictions on the Government's Use, Release, or Disclosure of Technical Data or Computer Software.

The Offeror asserts for itself, or the persons identified below, that the Government's rights to use, release, or disclose the following technical data or computer software should be restricted:

Technical Data or			
Computer Software			Name of Person
to be Furnished	Basis for	Asserted Rights	Asserting
With Restrictions*	Assertion**	Category***	Restrictions****
(LIST)*****	(LIST)	(LIST)	(LIST)

*For technical data (other than computer software documentation) pertaining to items, components, or processes developed at private expense, identify both the deliverable technical data and each such item, component, or process. For computer software or computer software documentation identify the software or documentation.

**Generally, development at private expense, either exclusively or partially, is the only basis for asserting restrictions. For technical data, other than computer software documentation, development refers to development of the item, component, or process to which the data pertain. The Government's rights in computer software documentation generally may not be restricted. For computer software, development refers to the software. Indicate whether development was accomplished exclusively or partially at private expense. If development was not accomplished at private expense, or for computer software documentation, enter the specific basis for asserting restrictions.

***Enter asserted rights category (e.g., government purpose license rights from a prior contract, rights in SBIR data generated under another contract, limited, restricted, or government purpose rights under this or a prior contract, or specially negotiated licenses).

****Corporation, individual, or other person, as appropriate.

*****Enter "none" when all data or software will be submitted without restrictions.

Date _____

Printed Name and Title _____

Signature _____

(End of identification and assertion)

(e) An offeror's failure to submit, complete, or sign the notification and identification required by paragraph (d) of this provision with its offer may render the offer ineligible for award.

(f) If the Offeror is awarded a contract, the assertions identified in paragraph (d) of this provision shall be listed in an attachment to that contract. Upon request by the Contracting Officer, the Offeror shall provide sufficient information to enable the Contracting Officer to evaluate any listed assertion.

(End of provision)

b. See also the following clauses recently added to Defense Federal Acquisition Regulation Supplement (DFARS):

252.209-7994 REPRESENTATION BY CORPORATIONS REGARDING AN UNPAID DELINQUENT TAX LIABILITY OR A FELONY CONVICTION UNDER ANY FEDERAL LAW--FISCAL YEAR 2014 APPROPRIATIONS (DEVIATION) (OCT 2013)

252.294-7012 SAFEGUARDING OF UNCLASSIFIED CONTROLLED TECHNICAL INFORMATION (NOV 2013)

VII. Agency Contacts

Should you have questions about a technical research area, contact the Program Officer 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@us.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 2 CFR 200.460, Proposal Costs (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 BAA-AFOSR-2014-0001.
7. 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.”

8. Federal Awardee Performance and Integrity Information System (FAPIIS)

There is a Government-wide policy on the use of the Federal Awardee Performance and Integrity Information System (FAPIIS) in the award of contracts and grants that may affect the agencies’ processes for judging proposed recipients to be qualified to receive contracts and financial assistance awards. The policy implements requirements of section 872 of the Duncan Hunter National Defense Authorization Act for fiscal year 2009 (Public law 110-417). For additional background information, see the Supplementary Information section in OMB’s proposal of the policy for comment, which appeared in the Federal Register on February 18, 2010 [FR 7316]. Note that the particulars of the proposed guidance and specifics of its application to grants may change when OMB issues the final guidance.

9. SAM Registration

Prospective awardee shall be registered in the SAM 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 <https://www.sam.gov>.

Awardees must:

- (a) Be registered in the System for Award Management (SAM) prior to submitting an application or proposal;
- (b) Maintain an active SAM registration with current information at all times during which it has an active Federal award or an application or proposal under consideration by an agency; and
- (c) Provide its DUNS number in each application or proposal it submits to the agency.

10. OMBUDSMAN

(a) An ombudsman has been appointed to hear and facilitate the resolution of concerns from offerors, potential offerors, and others for this acquisition. When requested, the ombudsman will maintain strict confidentiality as to the source of the concern. The existence of the ombudsman does not affect the authority of the Program Officer, contracting officer, or source selection official. Further, the ombudsman does not participate in the evaluation of proposals, the source selection process, or the adjudication of protests or formal contract disputes. The ombudsman may refer the party to another official who can resolve the concern.

(b) Before consulting with an ombudsman, interested parties must first address their concerns, issues, disagreements, and/or recommendations to the contracting officer for resolution. Consulting an ombudsman does not alter or postpone the timelines for any other processes (e.g., agency level bid protests, GAO bid protests, requests for debriefings, employee-employer actions, contests of OMB Circular A-76 competition performance decisions).

(c) If resolution cannot be made by the contracting officer, concerned parties may contact the Center/MAJCOM or AFISRA ombudsmen,

Ombudsman: Ms. Barbara G. Gehrs HQ AFRL/PK, Wright-Patterson AFB OH. telephone: (937) 904-4407; Email: barbara.gehrs@us.af.mil.

Concerns, issues, disagreements, and recommendations that cannot be resolved at the MAJCOM/DRU or AFISRA level, may be brought by the concerned party for further consideration to the U.S. Air Force ombudsman, Associate Deputy Assistant Secretary (ADAS) (Contracting), SAF/AQC, 1060 Air Force Pentagon, Washington DC 20330-1060, phone number (571) 256-2397, facsimile number (571) 256-2431.

(d) The ombudsman has no authority to render a decision that binds the agency.

(e) Do not contact the ombudsman to request copies of the solicitation, verify offer due date, or clarify technical requirements. Such inquiries shall be directed to the Contracting Officer.

11. Grant Payment Process

(a) All Grantees are expected to access Wide Area Workflow (WAWF) and complete WAWF's Standard Form (SF) 270, Request for Advance or Reimbursement, for payment. Grantees should submit SF 270s as expenses occur; however, Grantees should have no more than one month cash on hand at any given time.

(b) Each Grantee must register with WAWF at <https://wawf.eb.mil>. To begin the registration process, click on the accept button at the bottom of the page. WAWF will display the login page with a block for new users with hyperlinks to instructions for "Pre-registration for Vendors" and the actual registration link.

Please note that each Grantee must be registered in SAM and have an Electronic Business Point of Contact set up to approve new registrations within their Institution. Each Grantee will also need to set up a Group Administrator (GAM) to register their CAGE Code and DUNS number, in addition to setting up an organizational email address for email notification from WAWF advising on the status of vouchers submitted for payment. The Grantee will also need to contact the WAWF Help Desk to register their CAGE code within the WAWF system. WAWF Help Desk information is available at the WAWF web site.

(3) If you encounter any problems with your WAWF registration please click on "Vendor Customer Support" in the blue bar at the bottom of the login page. This link will provide phone numbers and an email address to the WAWF Help Desk.

12. AFOSR Policy on No Cost Extensions (NCE's)

AFOSR grants NCE's only in situations in which the extension is truly warranted and properly documented. AFOSR Agency Specific Requirements, 30 March 2012, which are incorporated into every AFOSR grant by reference, require prior written approval "to extend the period of performance, without additional funds, beyond the expiration date of the grant." For an extension to be granted, Articles 2 and 15 of the AFOSR Specific Requirements indicate recipients are to provide notice "in writing and with the supporting reasons and revised expiration date at least thirty (30) days prior to the expiration of the award." In no event will the period of performance be extended merely for the purpose of using unobligated balances. Institutions should make every effort to insure work is completed on time. If an institution deems an NCE is truly warranted, it should submit its request for an extension and supporting reasons to the relevant Program Officer.