AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

BROAD AGENCY ANNOUNCEMENT

OVERVIEW INFORMATION

The Air Force Office of Scientific Research (AFOSR), hereafter generally referred to as "we, us, our, or AFOSR," manages the basic research investment for the U.S. Air Force and Space Force. As a part of the Air Force Research Laboratory (AFRL), our technical experts discover, shape, and champion research within AFRL, universities, and industry laboratories to ensure the transition of research results to support U.S. Air Force and Space Force needs. Using a carefully balanced research portfolio, our research managers seek to foster revolutionary scientific breakthroughs enabling the Air Force, Space Force and U.S. industry to produce world-class, militarily significant, and commercially valuable products.

To accomplish this task, we solicit proposals for basic research through this general Broad Agency Announcement outlining the U.S. Air Force Defense Research Sciences Program. We invite unclassified proposals that do not contain proprietary information for research in many broad areas. We expect to fund only fundamental research. Our research areas of interest are described in detail in section A. Program Description.

We anticipate many awards in the form of grants, cooperative agreements, contracts, technology investment agreements, or other transactions. We reserve the right to select and fund for award all, some, part, or none of the proposals received. There is no guarantee of an award. Please review the entire announcement for full details.

Hyperlinks have been embedded within this document and appear as underlined, and or blue-colored words in the midst of paragraphs. The reader may "jump" to the linked section within this document by "clicking" (CTRL + CLICK, or CLICK).

SUMMARY FUNDING OPPORTUNITY INFORMATION

1. FEDERAL AWARDING AGENCY NAME

Air Force Office of Scientific Research
875 North Randolph Street, STE 325, Room 3112
Arlington, VA 22203

2. FUNDING OPPORTUNITY TITLE

Research Interests of the Air Force Office of Scientific Research

3. ANNOUNCEMENT TYPE

Amendment 0002

4. ANNOUNCEMENT NUMBER

FA9550-21-S-0001

5. CATALOG OF FEDERAL DOMESTIC ASSISTANCE (CFDA) NUMBER

12.800 Air Force Defense Research Sciences Program

6. KEY DATES

This announcement remains open until superseded. We review and evaluate proposals as they are received. You may submit proposals at any time; however, some specific topic instructions may recommend submission by specific dates that align with funding expectations.

7. NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM (NAICS) CODE:

The NAICS code for contracts under this announcement is 541715.

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A. PROGRAM DESCRIPTION

Our focus is on research areas that offer significant and comprehensive benefits to our national warfighting and peacekeeping capabilities. These areas are organized and managed in two scientific branches, each with two teams:

- Engineering and Information Sciences (RTA)
  - ENGINEERING AND COMPLEX SYSTEMS (RTA1)
  - INFORMATION AND NETWORKS (RTA2)
- Physical and Biological Sciences (RTB)
  - PHYSICAL SCIENCES (RTB1)
  - CHEMISTRY AND BIOLOGICAL SCIENCES (RTB2)

The research activities managed within each team are summarized below:

A.1. ENGINEERING AND COMPLEX SYSTEMS (RTA1)

The Engineering and Complex Systems team within the Engineering and Information Science Branch leads the discovery and development of the fundamental and integrated science that advances future air and space flight. The broad goal of the team 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 electronics, fluid dynamics, materials, propulsion, and structural mechanics are brought together in an effort to increase performance and achieve unprecedented operational capability. The team carries out its ambitious mission through leadership of an international, highly diverse and multidisciplinary research community to discover, shape, and champion new scientific discoveries that will ensure novel innovations for the future U.S. Air Force and Space Force.

The central research direction for this team 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.

The Engineering and Complex Systems (AFOSR/RTA1) Program Officers and topics are:

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.1.a.	Dynamic Materials and Interactions	Dr. Martin Schmidt
A.1.b.	GHz-THz Electronics	Dr. Kenneth C. Goretta
A.1.c.	Energy, Combustion, and Non-Equilibrium Thermodynamics	Dr. Chiping Li
A.1.d.	Unsteady Aerodynamics and Turbulent Flows	Dr. Gregg Abate
A.1.e.	High-Speed Aerodynamics	Dr. Sarah Popkin

A.1.f.	Aerospace Composite Materials	Dr. Ming-Jen Pan
A.1.g.	Multiscale Structural Mechanics and Prognosis	(Acting) Dr. Martin Schmidt
A.1.h.	Propulsion and Power	Dr. Mitat A. Birkan
A.1.i.	Agile Science for Test and Evaluation (T&E)	Dr. Brett Pokines

Our research areas of interest are described in detail below:

A.1.a. Dynamic Materials and Interactions

Program Description: The objective of this portfolio is to develop the fundamental scientific knowledge required to understand the dynamics of complex, heterogeneous and reactive materials for game-changing advancements in munitions and propulsion. The research areas supported by this portfolio therefore seek to discover, characterize, and reliably predict the fundamental chemistry, physics, hydrodynamics and materials science associated with the high energetics of explosives, solid propellant burning, and structural dynamics of materials subject to shock loading. The overall scope of the research in the portfolio will be accomplished through a balanced mixture of experimental, numerical, and theoretical efforts. The fundamental science of interest to this portfolio is necessary for revolutionary advances in future Air Force and Space Force weapon systems and their propulsion capabilities, including increased energy density, operational efficiency, effect-based optimization, and survivability in harsh environments.

Basic Research Objectives: Research proposals are sought in all aspects of the chemistry and physics of energetic materials with particular emphasis on chemistry-microstructure relationships and the fundamental dynamics of heterogeneous materials with complex structural properties. The problems of interest span multiple time and length scales, and strongly couple a broad range of physical phenomena, presenting fundamental challenges in experimental characterization, data assimilation, and model development. 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:

- New diagnostics for measuring the shape and speed of reaction fronts within well-characterized samples subject to various loading conditions. Ideally, this would require micro-meter and nano-second spatial and temporal resolution respectively. In addition, reliable transient pressure and temperature measurement during dynamic loading conditions would be invaluable, especially when conducted at high resolutions.
- Mesoscale experiments to understand the initiation of energetic materials (explosives) or reactive properties of solid propellants, including shock-loading and mechanical response of energetic crystals.

- Shock wave and detonation physics, including the quasi-steady and unsteady reacting front propagation, non-equilibrium effects, stability characterization, shock response of polymers, composites, and geological materials.
- Prediction of processing, structure, and property relationships in energetic materials, including reactive materials by design, and the ability to tailor stress waves and shock shapes from first principles, as an inverse design problem via microstructural and chemical properties.
- Novel, high energy density material compositions that overcome the CHNO limitations, including scale-up techniques required for gram-scale production and characterization
- Advanced mathematical and numerical techniques for multi-physics and multi-scale modeling and simulation (M&S) in energetic and other heterogeneous materials, aimed at developing new capabilities for numerical prediction of future munition technologies and their effects.
- Numerical simulation approaches that can span, in an integrated manner, multiple aspects of ordnance modeling: solid mechanics (penetration, perforation, survivability), reactive flow (fuse, detonation train, main fill), shock/structure interaction (case expansion, fragmentation), blast (compressible gas dynamics, afterburn), and damage to a target.
- Sub-detonative combustion of high explosives, e.g. deflagration. Our understanding of and ability to simulate deflagration of HE is severely lacking, yet it is important for various selectable effects concepts.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort.

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A.1.b. GHz-THz Electronics

Program Description: This program seeks scientific breakthroughs in materials, heterostructures, and devices that can lead to game-changing capabilities in digital electronics, RF sensing and amplification, transmit/receive functions, wideband operation, and novel functionalities. The primary frequencies of interest range from GHz to THz.

Basic Research Objectives: The focus of the portfolio is on fundamental interactions of electrons and quasiparticles with each other and their host materials in all regions of device operation. Technical challenges include understanding and controlling (1) interactions between particles/quasiparticles and host lattices, boundaries, and defects, including thermal effects and changes over time that limit lifetime and performance; (2) carrier velocity; and (3) methods of device operation that do not rely solely on conventional transistors or transport mechanisms such as drift, diffusion, and tunneling. Efficiency, volume, speed, and power are important figures of merit. It is expected that to understand

fully well the various new phenomena and device configurations, novel techniques to study and control nanoscale structures, defects, and operations may be required. Fundamental studies of radiation damage and its effects on properties and performance and of superconductors are of special interest. The program emphasizes experiments and also it supports theory and modeling.

Proposers are highly encouraged to contact the Program Officer prior to developing a white paper or proposal, preferably by email, to discuss the current state of understanding, how your research would advance it, and the approximate cost of a three- to five-year effort.

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A.1.c. Energy, Combustion and Non-Equilibrium Thermodynamics

Program Description: This portfolio addresses energy needs of Air Force aerospace systems for the propulsion and non-propulsive functions of increasingly significant energy requirements. The portfolio emphasizes three foundational elements: (1) Fundamental, (2) Relevant, and (3) Game-Changing, i.e.: starting from establishing fundamental scientific understanding and quantifying rate-controlling processes, focusing on Air Force/Space Force interests and relevant conditions, encouraging multi-disciplinary collaborations, interactions and unconventional and innovative thinking, leading to game-changing concepts and predictive capabilities for the Air Force and Space Force

Basic Research Objectives: Research topics in this portfolio include all energy aspects relevant to Air Force and Space Force needs, combustion and otherwise, with the following sub-areas**:**

Fundamental Combustion Understanding in Air Force Relevant Regimes: Combustion is the primary conversion process to supply energy for propulsion and other functions of aerospace systems such as planes, rockets, hypersonic and UAV systems. In these systems, the fuel combustion process occurs at highly turbulent flow conditions, governed by underlying molecular changes from high-energy states to lower ones, generating usable energy for system functions. The key turbulent combustion attributes are critical in determining operability, performance, size and weight of such systems. The understanding of these key attributes and the quantification of the inherent rate-controlling processes provide the scientific foundation of modeling/simulation capabilities needed for the design of new generations of AF aerospace systems. Based on recent progresses in understanding/modeling key chemical reaction pathways in combusting AF/DOD fuels and in exploring key attributes of turbulent flame structure and dynamics at relevant conditions, the turbulent combustion part of the portfolio currently focuses on exploring, understanding and qualifying the turbulent-chemistry interactions using physical and numerical experiments. This includes but is not limited to:

- Effects of turbulence on rate-controlling properties/processes of fuel combustion chemistry;

- Turbulent production by the energy release from combustion chemical reactions;
- Spatial/temporal scale interactions of turbulence structures and dynamics;
- Diagnostics for measuring key properties/processes in turbulent combusting flows.

Multi-Physics, Multi-Scale Modeling/Simulation for Energy Conversion:

Energy conversion processes in AF aerospace systems involves coupled multi-physics phenomena such as chemical reactions, turbulence, radiation, flow-material interactions, etc. in a wide range of spatial and temporal scales. Computationally efficient modeling/simulation capabilities with sufficiently low uncertainties, coupled with measured data, and assisted by artificial intelligence and machine learning will have game-changing impacts, potentially resulting in new, intelligent development & design tools for future aerospace systems. Such modeling/simulation capabilities may also be used to select and conduct "numerical experiments" to explore underlying physics at conditions where physical experiments are very difficult or impossible. Key focus areas are the physical foundation and numerical approaches for coupling multiple physical phenomena at different spatial and temporal scales, in particular:

- Embedded DNS (eDNS) – embedding "direct numerical simulation" (DNS being capable of resolving turbulence scales, down to the dissipative range, and detailed flame structures) into simulations for larger-scales such as large-eddy-simulations (LES) to provide needed resolutions/details in both small and large scales computationally efficiently;
- Coupling numerical simulations for different physics, e.g. coupling Eulerian fluid computations with Lagrange molecular dynamics calculations to provide information on critical properties needed in the larger-scale fluid calculations;
- Numerical techniques and algorithms for assimilating measured data into numerical simulations, to reduce the simulation uncertainty and to obtain quantitative information which is otherwise not available through experimental measurements alone.

Game-Changing Thermodynamics Concepts and Innovative Energy Conversion: Thermodynamics provides insights into energy conversion processes and the foundation to developing potentially game-changing energy-conversion approaches. It also establishes the thermodynamic foundation and framework to analyze the energy requirement and efficiency of propulsion systems and non-propulsive subsystem functions of increasingly significant energy needs. The following topics are of particular interest:

- Learning-based, intelligent thermodynamics framework for analyzing multi-scale, non-equilibrium physical and chemical processes, potentially leading to unconventional, game- changing energy conversion processes that potentially offer significantly higher than normal efficiency and other favorable attributes;
- Thermodynamics foundation and energy optimization for information processing systems.
- Novel, highly efficient approaches to electric propulsion.

- Other non-thermal, reduced-thermal and hybrid energy conversion processes, possibly of non-equilibrium nature, for future propulsion and subsystems, with particular interest in UAVs and robotic platforms;
- Combustion at extremely short time-scales, such as detonation-based processes (e.g. as potential game-changing propulsion approaches) and meld exothermic processes (e.g. biologically inspired energy conversion processes for UAV and robotic applications)
- Multi-functional fuels: (1) endothermic fuels and systems and (2) aviation fuels from new sources with economic and security advantages and related conversion processes;
- Unconventional formation mechanisms of large and complex carbon-based molecules, compounds and clusters at combustion, thermal or other interesting conditions, relevant to Air Force and Space Force propulsion, energy and other interests.

Proposers are highly encouraged to contact the Program Officer prior to developing a full proposal, preferably by email, to discuss the current state of understanding, how the research would advance it, the approximate cost for a three-to five-year effort, and if there are any specific submission target dates.

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A.1.d. Unsteady Aerodynamics and Turbulent Flows

Program Description: The Unsteady Aerodynamics and Turbulent Flows portfolio supports basic research into the dynamics and control of aerodynamic shear flows including the interactions of these flows with rigid and flexible surfaces in motion. The portfolio is interested in aerodynamic flows arising in both internal and external configurations and extending over a wide range of Reynolds numbers. The portfolio emphasizes the characterization, modeling, prediction, and control of flow instabilities, turbulent flows, and aerodynamic interactions. A 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.

Basic Research Objectives: Research in this portfolio is motivated, in part, by the fluid-structure interactions, by vortex and shear layer flows, by the aerodynamic performance of novel configurations, and by enduring questions on transitional and turbulent flows. The portfolio maintains an interest in the dynamic interaction between unsteady fluid motion, linear and nonlinear structural deformations, and aerodynamic control effectors for a wide range of flight regimes.

The portfolio seeks to advance fundamental understanding of complex, time- dependent flow interactions by integrating theoretical, numerical, and experimental approaches: studies integrating these elements to improve understanding are strongly encouraged.

Flow control studies are expected to involve an approach based on a fundamental insight into the flow dynamics. In cases where that insight may not exist, studies examining fundamental flow physics with a path to enabling control of the flow may be of interest. Flow control efforts integrating modeling, control theory, and advanced sensor and/or

actuator technology for application to a flow of interest are encouraged. Note that basic research of the variety typically funded by the portfolio may not yet have a clear transition path to an application, but nevertheless should be relevant to U.S. Air Force and Space Force interests.

Proposers are highly encouraged to contact the Program Officer prior to developing a full proposal, preferably by email to discuss the current state of the art in his/her area of interest, how the proposed research would advance it, the approximate cost for a three (3) year effort, and if there are any specific submission target dates.

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A.1.e. High-Speed Aerodynamics

Program Description: The flow field around a high-speed vehicle strongly influences its size, weight, lift, drag and heating loads. Therefore, research in this area is critical to the

U.S. Air and Space Force's interest in rapid global and regional response and space operations. This portfolio aims to lay the scientific foundation, through discovery, characterization, prediction and control of critical phenomena, for game-changing advancements in our understanding of high-speed, high temperature non- equilibrium flows around flying vehicles. External and internal transitional and turbulent wall-bounded flows are critical to the cadre of problems studied. Such understanding is a pre-requisite to making hypersonic flight routine.

Basic Research Objectives: Proposals are encouraged which leverage recent breakthroughs in other scientific disciplines and foster rapid research advancements in high-speed aerodynamics. It is encouraged that proposed efforts contain a balanced combination of experiments, computations and theoretical efforts. Flight experiments may be sought for obtaining data that cannot be obtained in ground facilities or by state-of-the-art computations. For any experiments proposed, explain how they capture the most sensitive variables for the problem being studied and how they can be used for validation of numerical models. For any numerical efforts explain which the hardest variables to accurately predict are and how the results will be validated with relevant measurements.

Innovative research is sought in all aspects of high Mach number (preferably M>5), high temperature, non-equilibrium flows with particular interest in (not in order of priority):

- Shock/Boundary Layer, Shock/Shock, and Shock/Separation interactions and unsteadiness for both external surfaces, and at the inlet and isolators for scramjets
- Turbulence - structure and growth, unsteady flow field characterization, effects of micro/macro particles in free stream, wall roughness, curvature, angle of attack, etc.
- Transition - Initial value and Eigen value approaches for transition prediction, stability analysis for different modes and multimode transition
- Diagnostics - to measure both the shock layer and the free stream disturbances
- Flow-structure interactions at hypervelocity conditions

- Development of physics-based models for air ro-vibrational-dissociation and ro-vibrational-translational processes that can: 1) be incorporated in CFD solvers without incurring orders of magnitude more time to solve a given problem. Experiments to validate the above models are also sought.
- Characterization of fundamental processes occurring between non-equilibrium flows and ablative surfaces
- Characterization of naturally occurring disturbances in the atmosphere at high altitudes
- Energy transfer mechanisms within high enthalpy flows
- Identification and characterization of high L/D shapes
- Flight experiments to realize basic science advancement in any of the above areas might be sought.

Ideas that don't strictly fall into the categories above, but are germane to high speed aerodynamics, are also welcome. You are highly encouraged to contact our Program Officer prior to developing a full proposal, in any sub-area, to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to four (4) year effort.

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A.1.f. Aerospace Composite Materials

Program Description: This program supports basic research in the design, processing, and characterization of novel composite materials to enable transformative enhancement in their performance through understanding of the chemistry, physics, and mechanics in heterogeneously structured materials. Such materials are aimed to significantly impact the structural design of future U.S. Air Force and Space Force platforms including airframes, space vehicles, satellites, and a multitude of load-bearing systems. Key scientific areas supported by the program include: materials discovery, collective phenomena in heterogeneous materials, innovative processing concepts, interface science, and new material behavior prediction tools.

Basic Research Objectives: Proposals are sought to advance the understanding of heterogeneously structured materials and the ability to conceptualize multiscale, hierarchical composite materials with collective properties not achievable in monolithic materials. Among the routes to achieving game-changing improvements in compositionally and topologically optimized materials, current emphases within the program are: (1) advanced materials with exceptional temperature capabilities; (2) design and processing of configurationally complex materials across multiple length scales; (3) understanding of interfacial phenomenon in heterogeneous systems; (4) concepts for integrated functionalities on the material level; and 5) computation and characterization methodologies to interrogate the behavior of heterogeneous materials in harsh environments.

On materials discovery, the priority is placed on high temperature capabilities in polymer resin, fibers/coatings/reinforcements, and ceramics. Potential approaches include, but are not limited to, new processing methodology, novel microstructural configuration by design, and/or material heterogeneity in multiple length scales. The utilization of topological arrangement (phase distribution on nano- to micro-scale), phase transformation, coupling effects, and material texture to optimize macroscopic properties is of interest. Topics of interest on materials processing include, but are not limited to, dynamic covalent polymers, polymer-derived ceramics, organic-inorganic hybrids, and field-assisted sintering. The proposed research must be based on fundamental understanding of the chemistry, thermodynamics, reaction mechanisms and kinetics, short- and long-range coupling, and/or structure-property relationships of the candidate materials. Metal-based materials, while not excluded, are not a priority for the program.

The understanding of the interface is important in heterogeneously structured materials. Research emphasis is on the intrinsic properties, time-dependent microstructural evolution, as well as nanomechanical and chemical interactions at the reinforcement-matrix interface. The incorporation of coating or interphase materials to manipulate interfacial characteristics for optimal collective behavior is also of interest.

Innovative concepts to incorporate additional functionalities in a structural composite material via hierarchical design and materials hybridization are of interest to the program. The functionalities may include, but are not limited to, acoustic, thermal, electrical, and electromagnetic properties. The research concept must show synergistic interactions between functional constituents. Note the emphasis is on the exploitation of heterogeneity and intrinsic properties of the constituent materials, not on the design of devices.

Research ideas on multiphysics, multiscale computational modeling that aims to understand and predict the behavior of topologically complex materials in harsh environments are sought. Concepts to elucidate and mitigate material degradation under ablative, plasma-rich, oxidative, and/or space radiation-present conditions are of particular interest. Experimental validation of the computational results is highly desirable. Advanced characterization techniques capable of isolating and quantifying material response on proper spatial and time scales are also of interest to the program.

You are highly encouraged to contact the Program Officer prior to developing a full proposal to discuss the current state-of-the-art how your research would advance it, and any submission target dates. To initiate the discussion, submit via email a short research summary that describes the fundamental science to be investigated. Alternatively you may submit pre-proposal that describes research concept, objective and approach, scientific significance, and the expected outcome. The pre-proposal is limited to two pages (text and legible graphics). A third page containing key references and short budget statement on the approximate cost for a three (3) to five (5) year effort may be included. The focus must be on fundamental science and not on solving an engineering problem. If the concept is considered of interest to the Aerospace Composite Materials program and funding is available, an invitation to submit a full proposal submission may be extended.

Sub-Research Areas

- High Temperature Constituent Materials
- Engineered Hybrid Materials

- Interface Science and Nanomechanics
- Multifunctional Materials
- Materials Behavior Prediction

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A.1.g. Multiscale Structural Mechanics and Prognosis

Program Description: This fundamental basic research program addresses the U.S. Air Force and Space Force needs in the following application areas: 1) New and revolutionary flight structures, 2) Multiscale 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 and Space 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 inherit shortcomings are of great interest.

Fundamental basic research issues of interest for multiscale 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 non-destructive evaluation (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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.1.h. Propulsion and Power

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, Nano-energetics in solid propellant combustion, High Pressure Combustion Dynamics in rocket engines, and structural batteries.

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, including plasma-based space propulsion systems and plasma-spacecraft interactions. 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 interest also includes the use of data-driven methods to generate dynamic databases for accurate, and efficient computational predictions. For Very low Earth Orbit, research is needed to identify and assess the suitability of new electric propulsion candidates that may make use of large amounts of beamed energy and the harvesting of air as a propellant. Concepts may include pulsed and/or continuous (steady-state) electric propulsion schemes that include understanding issues associated with efficient collection, conditioning, ionization, and subsequent acceleration of air to produce thrust at a sufficient specific impulse needed to maintain orbit. The potential use of beam energy introduces the possibility of directly coupling the beamed energy into ablative thrusters, or air flows for ionization to produce plasma ejections and thrust.

Research in the second area focuses on smart, functional Nano-energetics for propulsion purposes only. There has been tremendous progress in the synthesis and fabrication of Nano-sized 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 according to desired performance objectives and including controlling mechanisms at the nanoscopic and microscopic scale. Instead of being subject to uncontrolled combustion, smart Nano-energetics may be activated by external electromagnetic stimuli, such as an electrical field or light. For example, 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, to achieve extinguishment of a propellant, or to accelerate or slow a reaction with time or location.

Research in the third area would allow the Air Force and Space Force to capitalize on the higher efficiencies, and increased performance options made possible by taking rocket and other propulsion systems to increasingly high pressures. As this necessarily pushes materials and structures to correspondingly extreme limits, it becomes essential to take into consideration the dynamics of combustion processes, as higher pressures lead to increased amplitudes of fluid-dynamic and thermochemical events and fluctuations, in a wider spectrum of time scales. Mathematical and experimental analysis of these dynamics at higher levels of fidelity also lead to a "big data" problem. It becomes necessary to combine and dynamically integrate multi-fidelity simulations and experimental measurements or monitoring, with the goal of systematically performing modeling, analytics, statistics, and dynamic data driven validation for chemical propulsion.

Research in the fourth area aims to combine both electrochemical and mechanical functionalities in a single unit in which energy storage can be accomplished by materials and structures that simultaneously manage mechanical stress, including peak values encountered during launch.

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, Molecular Dynamics and Theoretical Chemistry, Mechanics of Multifunctional Materials and Microsystems, Computational Mathematics, and other programs as described in this announcement to find the best match for the research in question.

Proposers are encouraged to contact the Program Officer prior to developing a full proposal by email to discuss the current state of understanding, how the research would advance it, the approximate cost for a three (3) -to five (5) -year effort, and if there are any specific submission target dates.

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A.1.i. Agile Science for Test and Evaluation (T&E)

Program Description: The Agile Science for Test and Evaluation (T&E) program supports basic research inventing and innovating revolutionary capabilities responsive to the Air Force and Space Force T&E community. Crossing scientific frontiers necessitates enhancing and pioneering test and measurement capabilities. The program sponsors basic research in areas enabling metrology and facilitating correct and comprehensive interpretation of test information. Agile science of test and evaluation leads to improving the ability to analyze and model operational environments, pursue science discoveries, and accelerate research & acquisition. The AFOSR T&E program encompasses three broadly-defined, overlapping thrust areas: Autonomy, Hypersonics, and Cyber & Microelectronics. The Program is closely aligned with other AFOSR science areas advancing experimental methodologies and merging scientific disciplines.

Basic Research Objectives: The AFOSR T&E program is closely engaged with technical experts at the Air Force Test Center (AFTC) organizations including Arnold, Edwards, Eglin and Holloman Air Force Bases, who help guide 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, but are not limited to:

- 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, integralable models reducing requirements to test or help provide greater understanding of test results;
- Advanced algorithms and computational evaluation 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 methods to cyber vulnerability;
- New processes and devices that increase bandwidth utilization and allow rapid, secure transfer of test data to control facilities during test;
- 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 science that enable revolutionary test and measurement;
- Basic research in other T&E areas that advances the science of test and contributes to the development of knowledge, skills, and abilities for the AF T&E community.

You are highly encouraged to contact our Program Officer prior to developing full proposals to briefly discuss program alignment. You should be prepared to explain why your proposed effort should be considered basic research, how it is unique to Test Science, and demonstrate an awareness of the Air Force and Space Force T&E process.

Collaborative efforts with the Air Force Test Center and Air Force Research Laboratory are encouraged, but not required.

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A.2. INFORMATION AND NETWORKS (RTA2)

The Information and Networks Team within the Engineering and Information Science Branch is organized to support many U.S. Air Force and Space Force priority areas including

autonomy, space situational awareness, and cyber security. The research programs within this team lead the discovery and development of foundational issues in mathematical, information and network oriented sciences. They are organized along three themes: Information, Decision Making, and Networks.

The information theme addresses the critical challenges faced by the U.S. Air Force and Space Force which 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.

Closely aligned with the mathematical analysis of information is the need for autonomous decision making. Research in this theme 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.

Information analysis and decision making rarely occur in the context of a single source. The networks theme addresses critical issues involving how the organization and interaction among large collections of information providers and consumers contributes to an understanding of the dynamics of complex information systems.

The Information and Networks (AFOSR/RTA2) Program Officers and topics are:

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.2.a.	Computational Cognition and Machine Intelligence	(acting) Dr. Hal Greenwald
A.2.b.	Computational Mathematics	Dr. Fariba Fahroo
A.2.c.	Dynamical Systems and Control Theory	Dr. Frederick Leve
A.2.d.	Dynamic Data and Information Processing	Dr. Erik Blasch
A.2.e.	Information Assurance and Cybersecurity	Dr. Tristan N. Nguyen
A.2.f.	Mathematical Optimization	Dr. Warren Adams
A.2.g.	Science of Information, Computation, Learning, and Fusion	Dr. Richard D. (Doug) Riecken
A.2.h.	Trust and Influence	Dr. Laura Steckman
A.2.i.	Complex Networks	Dr. Donald K. Wagner
A.2.j.	Cognitive and Computational Neuroscience	Dr. Hal S. Greenwald

Our research areas of interest are described in detail below:

A.2.a. Computational Cognition and Machine Intelligence

Program Description: This program supports innovative basic research on the fundamental principles and methodologies needed to enable intelligent machine behavior, particularly in support of mixed-initiative (i.e., human-machine teaming) systems. The overall vision of this program is that future computational systems will achieve high levels of 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 and Space Force. This program covers the full spectrum of computational and machine intelligence, from cognitively plausible reasoning processes that are responsible for human performance in complex problem-solving and decision-making tasks, to non-cognitive computational models of intelligence necessary to create robust intelligent systems. Robustness in this context is 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. In the midst of this spectrum are the technologies explicitly needed to seamlessly incorporate intelligent computational systems into mixed human-machine teams. The program is divided into three sub-areas that span the full spectrum of computational and machine intelligence. They are: Computational Cognition, Human-Machine Teaming and Machine Intelligence.

The program encourages cross-disciplinary teams with collaboration including computer scientists, neuroscientists, cognitive scientists, mathematicians, statisticians, operation and management science researchers, information scientists, econometricians and game theoreticians, etc., especially when the research pertains to common issues and when collaboration is likely to generate bidirectional benefits. This program is aggressive, accepts risk, and seeks to be a pathfinder for U.S. Air Force and Space Force research in this area.

Proposals that may lead to breakthroughs or highly disruptive results are especially encouraged.

Basic Research Objectives: The Computational Cognition sub-area supports innovative basic research on high-order cognitive processes that are responsible for good human performance in complex problem solving and decision-making tasks – we only want to model the things people excel at. The sub-area also seeks to support research on building computational systems that derive from and/or integrate cognitive and biological models of human and animal intelligence. The overall objective is to understand and exploit these processes to create computational models that perform as well as or better than the reasoning systems they emulate. This sub-area seeks basic research that pertains to exploiting the capabilities of the mind and brain (human or animal) for creating more intelligent machines, as well as cognitively plausible mechanisms inspired by human (or animal) reasoning. This includes computational models based on human and animal

performance in perception, attention, memory, learning, reasoning, and decision making in order to improve machine performance.

This sub-area does NOT, however, support statistical approaches to machine learning (e.g., "Deep Learning"), or related variants, as fundamental science in that area is addressed by the Science of Information, Computation, Fusion and Learning program described elsewhere in this BAA.

The Machine Intelligence sub-area supports innovative basic research on fundamental principles and methodologies of computational intelligence necessary to create robust intelligent systems. These methodologies may be cognitively inspired, or non-cognitive in nature, taking full advantage of the strengths embodied in mathematical and computational systems, such as the ability to reason with complex formal logic. This sub- area encourages research enabling the creation of computational systems that embody intelligent behavior based on cognitively inspired or purely mathematical approaches.

Proposals that lead to advances in the basic principles of machine intelligence for memory, reasoning, planning, scheduling, and cognitively-inspired learning (i.e., NOT "Deep Learning" or other statistical means), action, and communication are desired insofar as these contribute directly towards robustness as defined above.

The Human-Machine Teaming sub-area is primarily concerned with the machine-side of mixed human-machine decision-making, which appears at all levels of U.S. Air Force and Space Force operations and pervades every stage of U.S. Air Force and Space Force missions. To that end, 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. This sub-area seeks new empirical and theoretical basic research that enables intelligent machines to perform as true "teammates," adapting their behavior to accommodate changes in the environment, as well as augmenting the performance of human teammates when needed. This includes basic science in collaborative human-machine teams to aid the machine-side of inference, analysis, prediction, planning, scheduling, and decision making.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.2.b. Computational Mathematics

Program Description: This program seeks to develop innovative mathematical methods and fast, reliable and scalable algorithms aimed at making radical advances in computational science and large-scale engineering and design. Research in computational mathematics underpins the fundamental understanding of complex physical phenomena

and leads to predictive simulation capabilities that are crucial to the design and control of future U.S. Air Force and Space Force systems, and their lifetime expectancy.

Proposals to this program should focus on fundamental scientific and mathematical innovations, and should have the potential to address some of the most important computational challenges in science and engineering. Additionally, it is desirable to frame the basic research ideas in the context of applications relevant to the U.S. Air Force and Space Force, which can serve simultaneously to focus the research and to provide avenues for transition of basic research outcomes into practice. Applications of current Air Force and Space Force interest include, but are not limited to, quantum physics and quantum information systems, plasma dynamics, turbulence (e.g., in fluids, combustion, plasma), lasers and directed energy, aero-thermo-dynamics, information science, data analysis (including machine learning), biophysics, and material and structural sciences.

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 derived from physical models. However, alternative computational approaches are of keen interest, particularly in connection with emerging and multidisciplinary applications. Increased emphasis in this portfolio is placed on approaches that can handle a very high number of dimensions, uncertainty and stochasticity for non-Markovian processes, far from equilibrium conditions, and/or a wide range of scales (space, time, physical parameters, or complexity). Research areas of particular interest currently include:

- Mathematical methods for complexity reduction of high-dimensional, non- linear and multiscale problems, e.g., via projection-based methods and/or new machine-learning concepts. Such systems may have continuous, discrete or mixed representations, and may reside on graphs with evolving topology.
- Mathematical approaches to the modeling of non-equilibrium statistical processes and turbulent dynamics with multiple physical interactions and large parameter spaces; of special interest are methods which effectively allow bi- directional transfer of information across scales, and can simultaneously reduce the computational burden while preserving the correct physics of interaction, including conservation laws and instability regimes.
- Highly efficient and accurate methods for high-dimensional, nonlinear and stochastic dynamics with constraints. In particular, we are seeking revolutionary approaches to solving Hamilton-Jacobi-Bellman equations, optimal transport problems, and inverse problems for highly complex conditions. Of particular interest are applications in large-scale game theory, self-organized criticality and cascades, and the prediction of rare and extreme events.
- Traditional computational methods involving high-order spatial and temporal algorithms remain of interest, if they have the potential for significant breakthrough and are able to meet the formidable computational challenges associated with current and future engineering problems of interest to the U.S. Air Force and Space Force.

The list above is not exhaustive and other approaches can be suggested to the Program Officer, who can then determine if a proposal is warranted and of potential interest. All proposed methods must be innovative, have quantifiable measures of fidelity, efficiency

and adaptively, must be based on rigorous analysis and preferably demonstrated on canonical challenge and grand challenge problems.

You are encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.2.c. Dynamical Systems and Control Theory

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 and Space Force systems. Proposals should focus on the fundamental science and mathematics, while having relevance to future Air Force and Space Force systems and operations. These applications currently include information systems, as well as autonomous/semi-autonomous aerial vehicles, munitions, and space vehicles. Note that research specifically aimed at an Air Force and Space Force application may not be considered fundamental research; therefore, future Air Force and Space Force applications should be mentioned as examples or possibly motivations for fundamental theory in dynamical systems and control theory.

The dramatic increase in complexity of Air Force and Space Force systems provides unique challenges for the Dynamical Systems and Control Theory Program. Meeting these challenges may require interdisciplinary approaches as well as deeper studies within single disciplines.

Lastly, note that the Dynamical Systems and Control Theory Program places special emphasis on mathematically rigorous 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: methods of dynamical analysis of complex systems for the purpose of real-time control; control of ensemble and infinite dimensional systems; deterministic time and/or real-time reachability and viability set calculation and verification and validation of hybrid systems with formal specifications; distributed and decentralized decision making and control for coordinated autonomous/semi-autonomous aerospace vehicles with realistic nodal dynamics (e.g., not linear consensus or linear estimation over graphs), considering constraints, uncertain, information rich, dynamically changing, networked environments with time-varying topologies; novel schemes that enable challenging multi-agent aerospace tracking in complex, cluttered scenarios; robust and adaptive non-equilibrium (e.g., set-based) 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 where uncertainty distribution is non-Gaussian; novel theory for control of hybrid 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, the control of large complex, multi-scale, hybrid, highly uncertain nonlinear systems is of increasing interest. Furthermore, new mathematics in clear support of dynamics and control is of fundamental importance to this portfolio. In this regard, some areas of interest include, but are not limited to, hybrid dynamical systems theory, geometric and algebraic methods of dynamics and control, stochastic and adversarial systems, control of cyber physical systems with formal specifications, emerging areas of control theory, graph theoretic control theory over nonlinear dynamics at nodes of graphs, partial and corrupted information, nonlinear control and estimation, and novel computational techniques specifically aimed at control of systems with large data.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort.

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A.2.d. Dynamic Data and Information Processing

Program Description: The portfolio seeks mathematical concepts that dynamically incorporate additional data, whether measured or from models, into an executing application to coordinate dynamic measurement collections, model refinements, and system awareness. Examples include dynamic data driven applications systems (DDDAS), physics-enhanced machine learning (PEML), and physics-based and human-derived information fusion (PHIF), Key developments should harness the use of first-principle models towards real, simulated, or augmented signals, data, and information processing to obtain substantial comparative improvements over existing methods. The portfolio encourages multidisciplinary research, especially synergistic and systematic collaborations between domain researchers in engineering, mathematics, computer sciences for multiresolution systems modeling, diagnostics, and analytics.

Basic Research Objectives: Foster individual and multidisciplinary research, technology development, and system analysis over emerging science and technology frontiers.

Domain Modeling: Methods leveraging large-scale simulations for real-time control, in concert with heterogeneous data collection, model updates, and system processing. Research advances should describe different levels of detail and modalities, invoke appropriate models, and interface with other data systems. For example, ideas to engender an integration of large-scale simulations, models, and data to advance traditional data processing paradigms.

Mathematical and Statistical Algorithms: Design methods for stable and robust convergence properties under perturbations induced by time-dependent (periodic and non-periodic, scheduled and event-driven) data inputs, multiple scales and model variations. Address enhanced asynchronous algorithms with stable communication between networked resources, multimodal modeling, and uncertainty quantification. For example, concepts to dynamically invoke models requiring elegant methods of uncertainty quantification, management, and propagation.

Measurement Systems and Methods: Innovate instrumentation platforms for collecting data, registering measurements, controlling sampling rates, and multiplexing multisource information. For example, designs to determine heterogeneous and embedded distributed sensor networks architectures, information fusion paradigms, and operationally robust performance.

Areas of interest to the Air Force and Space Force include

- Autonomy (e.g., leveraging large-scale modeling of mission planning, collaborative/cooperative control, and data learning for data analytics);
- Agility (e.g., designing computational methods of sensor-based processing, ad-hoc network configurations, and multi-scale multi-physics simulations for decision support);
- Authority (e.g., coupling high-performance aircraft health monitoring, space situational awareness, and ground operations for command and control);
- Robustness (e.g., understanding materials stresses and degradation; embedded diagnostics, complex adaptive systems verification and validation, and cognitive performance augmentation for situational understanding).

New approaches are encouraged for combining computational, empirical, cognitive, theoretical, and analytical methods for interactive testing of multiple scientific and engineering hypotheses. Programmatic activities launched under this initiative will support research in individual areas of interest to the Air Force Research Laboratory, but mostly in the context of multidisciplinary research across the Basic Area Objectives mentioned above.

You are highly encouraged to contact the Program Officer prior to developing a full proposal to discuss the current state-of-the-art, how your research would advance it, the approximate cost for a two (2) to three (3) year effort, and if there are any specific submission target dates.

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A.2.e. Information Assurance and Cybersecurity

Program Description: Securing cyberspace, i.e. defending against and preventing cyber-attacks are not new challenges but these have become increasingly pressing in the light of

technological advancements. Software and protocols are continuously becoming more complex to meet application demands. More flexible computing environments, such as distributed systems, demand new ways of thinking how to ensure secure end-to-end functionalities, even though components are only known to be individually secure. The emergence of nanoscale devices and quantum information processing and communication also portends new technological challenges for cybersecurity. By the same token, these new technologies potentially offer unparalleled security solutions to the existing or future problems.

Although engineering practices continue to provide short-term and temporary relieves to these pressing needs, new scientific ideas are required to address the lack of security and the explosive growth of hostile actions in cyberspace, especially taking into account of emerging technologies. Many fundamental concepts are still eluding precise formulation and awaiting rigorous responses. The goal of this Basic Research program is to explore novel, promising concepts and methodologies that can establish a firm scientific foundation for cybersecurity and potentially tackle the difficult technical hurdles described above.

Basic Research Objectives: Recent developments and advances in the following research areas of computer science and mathematics are expected to provide valuable insights into various cybersecurity problems: dependent type theory, cryptographic protocols for interactive computation and communication, interactive and automated theorem proving, language-based techniques in software and hardware for formal specification and verification, secure protocols, game theory with strong security content, obfuscation and fully homomorphic encryption, model categories, formalized mathematics. Broadly speaking, cross-fertilization of mathematical formalisms and logical constructs will likely continue to play a central role in the construction and verification of security invariants, and in the study of security models or security principles.

These scientific advances are expected to contribute fresh ideas to a number of fundamental cybersecurity topics: composition of security properties and protocols in distributed interactive systems without the need of trusted third parties; rigorous techniques to enable persistent and secure operations on unsecure or untrusted systems; information flow security and non-interference in dynamic and distributed settings; new security invariants that can readily be computed and interpreted, especially for systems endowed with rich geometric dynamics; rigorous proofs and construction of obfuscation techniques for programs and circuits to enhance security; formal verification and certification of the correctness of complex large-scale mathematical proofs and critical computer systems.

Aside from software and secure protocols, nanoscale material properties and quantum effects should offer added security capabilities for future computing devices that cannot be realized by today's technologies. They potentially enable physical construction of cryptographic primitives that are traditionally described by algorithms and typically implemented by software. Random Number Generators and Physical Unclonable Functions are simplest examples of such construction. At the same time, securing future unconventional technologies will require the introduction of new security principles and security models that may substantially deviate from the traditional approaches. In fact, various concepts in quantum information science and quantum computation such as quantum resources (entanglement, non-locality, contextuality, etc.) and quantum

computational/communication complexity are highly relevant to the security of future communication and computing systems in which classical and quantum devices interact.

Research areas of interest to this program include, but are not limited to, the methodologies and topics described above. Highest priority will be given to projects with novel scientific ideas that potentially deliver new DoD/Air Force and Space Force capabilities.

You are highly encouraged to contact the Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.2.f. Mathematical Optimization

Program Description: The program goal is to develop novel theory, algorithms, and software for the many classes of Mathematical Optimization problems that arise in support of decision, design, and allocation problems confronting the US Air Force and Space Force. Areas of fundamental interest include resource allotment, planning, logistics, interdiction, engineering design, resiliency, and scheduling. Problems can be deterministic in that input parameters and objectives are known with certainty, or can have data uncertainty that is addressed using such methods as stochastic programming and robust optimization. The research, while of fundamental importance to such type problems, can also profoundly impact related areas of study, including the operation of autonomous vehicles and the effectiveness of machine learning.

Basic Research Objectives: The program welcomes basic research in theory, algorithms, and computational methods for continuous and discrete problems, both deterministic and stochastic. Contributions/impacts can be generally applicable to large families of problems, or be specially tailored to exploit specific mathematical structures found within special, important classes. As basic research aimed at having the broadest possible impact, the development of computational methods should include an emphasis on theoretical underpinnings, on rigorous convergence analysis, and on establishing provable bounds for approximation methods. Areas of interest include, but are not limited to:

- Integer and mixed-integer programming
- Continuous, nonconvex optimization
- Multi-level optimization
- Conic programming
- Combinatorial optimization
- Stochastic programming

Methodologies include:

- Cutting plane and polyhedral methods for mixed-integer programs
- Decomposition methods for large, specially-structured problems
- Global optimization for nonconvex programs
- Interior-point and first-order algorithms for conic/nonconvex optimization

The suggested application process is as follows. Submit an approximate four-page white paper to the Program Officer that summarizes the research to be performed, the importance, the approach, a brief summary of qualifications, and an estimate of the total cost. If desired, additional pages can describe qualifications and bibliography.

The paper should not be overly-technical but instead provide a clear description of the problem(s) to be solved, the approach and novelty, and the potential application to DoD missions. Then, depending on such factors as reviews and available budget, select white papers will be chosen for full-proposal development. *A key evaluation criterion is the identification of innovative idea(s) that show promise for advancing the field of mathematical optimization, with reference to the optimization/mathematical programming literature.*

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A.2.g. Science of Information, Computation, Learning, and Fusion

Program Description: The U.S. Air Force and Space 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 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 and probabilities. 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 processes 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, computation, and learning that can support processing and making sense of complex disparate information sources. After all, information processing can formally and fundamentally be described as computing and reasoning on various knowledge representations. Successes in addressing the research sub-areas stated below would give the U.S. Air Force and Space Force new capabilities to: (1) shift emphasis from sensing to information awareness; (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, computing science, statistics and logic which have potentials to: (1) cope with various complex disparate data/information types; (2) integrate a diversity of unique reasoning and learning components collaborating simultaneously (e.g., multi-strategy reasoning and learning); (3) bridge correlational with causal discovery; (4) determine solutions or obstructions to local-to-global data- fusion problems; (5) mechanize reasoning/learning 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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.2.h. Trust and Influence

Program Description: The Trust and Influence program funds interdisciplinary high risk, transformative basic research that (1) elucidates the social and cognitive principles and processes surrounding the establishment, maintenance, and repair of trust between and among humans and intelligent agents, machines, algorithms, and/or other emergent technologies, with particular interest in situations where these concepts apply to heterogeneous, distributed teams or teaming constellations (i.e. teams of teams); and (2) advances the science of social influence that consider how the phenomena and/or associated processes shape or affect human beliefs, perceptions, attitudes, and/or behaviors. The program encourages multidisciplinary and transdisciplinary approaches, which may include contributions from sociology, anthropology, computer science, psychology, cognitive science, linguistics, mathematics, economics, computational social science, and other social or behavioral sciences. It further encourages research designs that utilize laboratory studies, modeling, and/or field research intended to develop novel, transformative theories, frameworks, or evaluative measures.

Basic Research Objectives: The program's research themes can be defined broadly by two areas: trust in autonomous systems, human-machine teaming, and emergent technologies; and influence. In the area of trust in autonomous systems, human-machine teaming, and emergent technologies, there is particular interest in (1) empirical studies to

examine drivers of trust between/among humans and intelligent, autonomous agents that operate in various configurations of heterogeneous, distributed teams or constellations; (2) laboratory and field studies to examine the impact of socially-designed and/or culturally-specific cues or physical features such as appearance, voice, personality, and other social elements related to human trust and system performance; (3) development of trust metrics, evaluative frameworks, and other relevant constructs in human-machine or human-agent teaming with a particular emphasis on real-time evolving and dynamic assessment; and (4) modeling of human-machine or human-autonomy teaming or joint action that supports adaptive and continuous improvement of joint performance in complex environments.

In the area of influence, research is needed to understand how vectors of information, such as but not limited to social and digital media channels, contribute to short- and long-term campaigns intended to influence populations, shape perceptions, spread ideas, alter or diffuse narratives, and change beliefs. The portfolio is concerned with sociobehavioral and technosocial effects and the cognitive processes that give rise to behavior and those that contribute to how populations either become more susceptible or resilient to influence. The program does not fund projects that examine disinformation unless they are appropriately situated within the larger information ecosystem and/or multi-vector informational influence campaign(s). There is a need for laboratory and field studies to reveal (1) effects of influence and persuasion that occur within the information environment through one or more vectors of information, such as social and digital media, and across different cultural groups; (2) social/sociocultural, cognitive, and neural mechanisms of influence and persuasion; (3) new or revised theories of resonance that consider the cognitive, emotional, sociocultural, and psychological impact of new media; (4) modeling and measurement of the relationship between online and real-world behaviors; and (5) empirical studies to discover new theories of influence that examine unknown or understudied influence vectors that individually or in combination impact human cognition or behavior.

Potential topics that would be of interest to the program include, but are not limited to, those listed above. Innovative ideas that reflect the program's general objectives and approach the science of trust and/or influence relying on different definitional interpretations or disciplinary perspectives may be considered; novel ideas that combine trust and influence, such as those related to the basic science underlying persuasive technologies, are also encouraged.

Proposers are highly encouraged to contact the Program Officer prior to developing a full proposal, preferably by email, to discuss the current state of understanding in the field(s); how the research would advance it; proposed or potential research questions or hypotheses; the approximate cost for a three- to five-year effort; and specific submission target dates.

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A.2.i. Complex Networks

Program Description: Complex networks are pervasive in military, commercial, and civilian operations. Complex networks consist of a graph (directed or undirected) together with a set of attributes. These attributes can include scalar or multi- dimensional weights

on the edges or nodes of the graph, topological characteristics of the graph, flows over the graph, and processes that define the dynamics of the graph. Complex networks cut across many scientific disciplines (e.g., mathematics, computer science, engineering, socio-economics, etc.) and many application domains (e.g., communications, sensing, information systems, transportation, etc.). Networks fundamentally describe the structural aspects of interactions between individual agents. Networks can be extremely large and can have multiple characteristic scales. They can be static or dynamic. They can be physical or virtual. Networks can consist of multiple heterogeneous subnetworks (i.e., a network- of-networks), with explicit and implicit interdependencies. For example, transportation networks are intimately coupled to computer and electrical-power networks. Thus, the failure of a critical node or arc in one network can trigger failures in another, which can create a cascade event with catastrophic consequences. All of these characteristics of networks can make the analysis, understanding, and utilization of networks difficult and computationally prohibitive.

This basic-research program is focused on developing fundamental mathematical and algorithmic techniques to design, analyze, utilize, and understand complex networks. The program seeks innovative approaches with far-reaching potential, meaning any mathematical and algorithmic approaches ideally should be applicable to broad classes of problems and not tied to a particular application domain. The networks of interest can have arbitrary topologies, can be static or dynamic, and can be subject to uncertain conditions, ranging from a stochastic environment to deliberate adversarial actions affecting both nodes and links.

Basic Research Objectives: This program is aimed at developing mathematical and algorithmic tools for the design, analysis, understanding, and utilization of complex networks. Problems of interest include, but are not limited to:

- Network resilience and robustness: This includes techniques for defining and measuring the resilience of a dynamic network; techniques for predicting, identifying, and mitigating adversarial actions against a network; techniques for network interdiction.
- Network analytics: This includes algorithmic techniques for solving important classes of problems on networks, such as optimal resource allocation and information dissemination; algorithmic techniques for inference problems on networks that extract global information about network structure and function from local information. The algorithms can be exact or approximate with performance guarantees. Of particular interest are decentralized algorithms and understanding the tradeoff between centralization and decentralization.
- Complexity reduction of networks: This includes techniques for decomposition, sparsification, and dimensionality reduction of networks with the goal of making networks easier to analyze, understand, and visualize; techniques for analyzing and exploiting graph-theoretic structure such as multi-layer networks.
- Extension of network-analysis techniques to more general combinatorial, algebraic, or analytical structures: This includes network-relevant research in submodular functions, hypergraphs, matroids, graphons, etc.

Approaches may draw upon, but are not limited to, techniques from graph theory, optimization, complexity theory, algorithmic game theory, combinatorics, linear algebra, statistics, and probability.

You are highly encouraged to contact the Program Officer, preferably by email, prior to developing a full proposal, to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost, and if there are any specific submission target dates.

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A.2.j. Cognitive and Computational Neuroscience

Program Description: The Cognitive and Computational Neuroscience program funds high-risk, high-potential basic research that uses experimental and computational modeling techniques from systems neuroscience, cognitive neuroscience, computational/theoretical neuroscience, cognitive science, and cognitive psychology to **(1) understand the neural mechanisms responsible for perception, cognition, and behavior/motor control**. The program also supports **(2) brain-inspired algorithm and hardware development** provided these are useful for testing proposed neuroscience theories and/or enabling novel capabilities in computing, artificial intelligence, or autonomous systems.

Basic Research Objectives: The program funds basic research in cognitive and computational neuroscience and at the intersection of neuroscience and artificial intelligence as described above. Potential topics that would be of interest to the program include but are not limited to the following examples. Innovative ideas that may not fit into these categories but are germane to the program's general objectives are also welcomed.

- *Neural Information Representation.* It is well established that neurons communicate information via action potentials ("spikes"), but understanding how neurons represent information has remained a long-standing challenge. Debates continue regarding whether neurons use precise spike timing or frequency to encode information, the functions of noisy, probabilistic population codes, and whether every spike carries signal. Proposed research projects should characterize neural activity with the aim of reliably decoding neuronal information. Proposers should describe how their research, if successful, will advance our ability to test hypotheses regarding neural mechanisms and functions and/or enable greater sophistication for applications such as sensory and sensorimotor prosthetics, brain-machine interfaces, and deception detection.
- *Bio-inspired Sensing.* Recent examples of commercially-developed neuromorphic hardware have focused on power consumption and density advantages over conventional hardware, but brain-inspired circuits also hold promise for novel computing architectures that can address problems that traditional von Neumann architectures cannot (or at least not within polynomial time or better). Research proposals on brain-inspired computational capabilities should describe how the research will fill gaps in computing or how it will enable novel artificial intelligence algorithms.

- *Brain-inspired Machine Learning.* Current machine learning algorithms excel at identifying statistical features in complex data sets, yet computers lack the robustness and generalizability associated with human learning. Specifically, humans can leverage previously learned knowledge to avoid needing large training sets, transfer knowledge from one task to other related tasks or contexts to accelerate learning, continuously update their learned knowledge, and adapt to time-varying contexts and environments. The program seeks to create brain-inspired or biomimetic algorithms that advance the state of the art and have the potential for revolutionary progress on these or related research challenges.
- *Brain-inspired Computing.* Recent examples of commercially-developed neuromorphic hardware have focused on power consumption and density advantages over conventional hardware, but brain-inspired circuits also hold promise for novel computing architectures that can address problems that traditional von Neumann architectures cannot (or at least not within polynomial time or better). Research proposals on brain-inspired computational capabilities should describe how the research will fill gaps in computing or how it will enable novel artificial intelligence algorithms.

Models of brain structures and functions should be biologically plausible and demonstrate consistency with the current understanding of the structure and function of the brain components being modeled. Brain-inspired algorithms or hardware need not remain entirely faithful to the biological details where other approaches are more reasonable, but neuroscience evidence should be used for benchmarking and theoretical guidance. Proposals should provide a definition of success based on specific metrics and/or one or more challenge problems.

Prospective proposers are highly encouraged to contact the Program Officer prior to developing a full proposal to discuss the proposed research and how it will advance the state of the art, the approximate cost for a three- to five-year effort, and any specific submission target dates.

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A.3. PHYSICAL SCIENCES (RTB1)

The Physical Sciences Team 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 and Space 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 the following four broad areas, with the focus on advancing our basic understanding of the physical world:
(1) Quantum matter and devices; (2) plasma and high-energy-density physics; (3) optics, photonics, and electromagnetics; and (4) aerospace materials.

The Physical Science (AFOSR/RTB1) Program Officers and topics are:

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.3.a.	Aerospace Materials for Extreme Environments	Dr. Ali Sayir
A.3.b.	Atomic and Molecular Physics	Dr. Boyan Tabakov
A.3.c.	Electromagnetics	Dr. Arje Nachman
A.3.d.	Laser and Optical Physics	Lt Col Briana Singleton
A.3.e.	Optoelectronics and Photonics	Dr. Gernot S. Pomrenke
A.3.f.	Plasma and Electro-Energetic Physics	Dr. John Luginsland
A.3.g.	Quantum Information Sciences	Dr. Grace D. Metcalfe
A.3.h.	Physics of Sensing	Dr. Michael Yakes
A.3.i.	Space Science	Dr. Julie J. Moses
A.3.j.	Ultrashort Pulse Laser-Matter Interactions	Dr. Andrew Stickrath
A.3.k.	Condensed Matter Physics	Dr. Jiwei Lu

Our research areas of interest are described in detail below:

A.3.a. Aerospace Materials for Extreme Environments

Program Description: Aerospace Materials for Extreme Environments program aims to provide the fundamental knowledge required to enable revolutionary advances in future U.S. Air and Space Force technologies through the discovery and characterization. Extreme environments are combination of heat-, stress-, magnetic-, electric-, microwave-, and acoustic fields. Materials of interest are ceramics, metals, and hybrid systems including inorganic composites that exhibit superior structural, functional and/or multifunctional performance.

Basic Research Objectives: The following research concentrations areas are selected to highlight the philosophy about function, environment and state of the materials that could create disruptive source of transformations.

Computational Materials Science: The aim of this research concentration area 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 these metrics, 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).

Synthesis Science and 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 and processing science approaches that are far from the thermodynamic equilibrium domain; i.e., materials for quantum sciences, adaptive oxides, multiferroics, frustrated structures (layered structured materials), highly doped polycrystalline laser materials, and other non-equilibrium materials. This area requires understanding of super saturation of lattice-structure and manipulation of lattice substructure by understanding elastic softening of a lattice containing a critical amount of dopants, which could lead to an order disorder transition with further super saturation. The intent is to elucidate complex interplay between phase transitions for electronic/magnetic phase separation and untangle the interdependence between structural, electronic, photonic and magnetic effects.

Hypersonic Material: This topic area includes a wide range of activities of hypersonic 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. The ultimate goal is to exploit these phenomena and design future materials, sensors and components for hypersonic environments.

Combined External Fields: This subtopic also 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 of extreme fields; i.e., dielectric breakdown at high temperatures. The aim is to link an effective property to relevant local fields weighted with certain correlation functions that statistically exemplify the structure and demonstrate scientific pathway to design new materials with tailorable properties.

Researchers are highly encouraged to contact the Program Manager 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 (3) to five (5) year effort.

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A.3.b. 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, matter-wave optics, and non-equilibrium quantum dynamics. These research areas support technological advances in application areas of interest to the U.S. Air and Space Force, including precision navigation, timekeeping, remote sensing, metrology, and novel materials for the U.S. Air and Space 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 ultra-cold 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; precision control techniques; strongly-interacting quantum particles; new quantum phases of matter; non-equilibrium dynamics of cold quantum particles; ultra-cold chemistry; precision spectroscopy; and high-precision techniques for navigation, guidance, and remote sensing.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.3.c. Electromagnetics

Program Description: This portfolio supports basic research (modeling/simulation/experiment) in linear/nonlinear Electromagnetics together with research in the general area of signal processing.

Basic Research Objectives: Basic research to produce conceptual/experimental 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. Also of interest is temporal modulation of physical parameters of various components. Such a dynamically induced non-reciprocity can lead to a new generation of compact and energy efficient isolators, circulators, phase shifters, and other non-reciprocal optical and microwave devices. Basic research in inverse scattering theory in order to promulgate new methods which recognize & track targets or upgrade efforts to pursue Nondestructive Evaluation is encouraged. Efforts to identify suitable wideband waveforms to penetrate foliage, clouds, buildings, the ionosphere, or other dispersive/random/turbulent media as well as to notionally 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. together with 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 non-equilibrium 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. As regards the signal processing component, 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 component 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 video and multi-spectral data. New combinations 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 non-inertial navigation methods (including optical flow and use of signals of opportunity) will bring location precision and reliability to a superlative level.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to discuss alignment of your ideas with our program goals, your proposed methods, and the scope of your proposed effort.

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A.3.d. Laser and Optical Physics

Program Description: The Laser and Optical Physics portfolio seeks to study the fundamental properties of laser light to advance its development and understanding through basic research and discovery in direct support of Air and Space Force research and development interests. Novel laser light sources are also an objective of the program, particularly in regions of the spectrum otherwise not easily accessible. Of concern is laser light interaction with organic and inorganic matter to include synthetic, naturally occurring, and biological materials. To this end theoretical, experimental, and computational research is desired to investigate the optical physics phenomena of near monochromatic light both spatially and temporally to include but not limited to optical and imaging physics, non- linearity, and the study of the quantum mechanical properties associated with laser-matter interaction. The programmatic goals are to advance the science of laser devices, laser materials, laser-matter interaction, nonlinear optical phenomena, associated optical and imaging physics, and the potential for the laser's unique application to solve scientific and technological problems of interest to the United States Air and Space Forces.

Basic Research Objectives: By their nature, lasers and laser-matter interaction require a multidiscipline approach to the realm of associated photonics that includes but is not

limited to optics, atomic and molecular physics, biophysics, biomedical optics, quantum mechanics, and synthetic, naturally occurring, and biologically related materials science. Our goals are to discover and push the limits of the operation of lasers, amplifiers and related optical and electro-optical systems to control and produce light beams or pulses with well-defined parameters, and to exploit the dynamics of the interaction of intense, coherent light with matter regardless of the physical science discipline that allow for new discovers.

On the other end of this spectrum, this program supports fundamental science in lasing processes in solids, liquids, gases, and plasma, and research that enhances the power, energy, beam quality and waveform stability of lasers across the wavelength spectrum for Directed Energy research and development. Examples include novel processing techniques for high quality solid-state laser materials with control over spatial distributions of dopants and index of refraction, and processing methods for achieving low-loss lasers. New ideas for high average power fiber lasers are of interest, including new materials, and large mode area structures. New ways of mitigating nonlinear instabilities, and studies of coupling multiple fiber lasers, which can withstand very high average power.

More broadly, the Laser and Optical Physics portfolio will consider any cutting-edge and potentially transformational ideas, and is especially interested in inter-disciplinary research, within the broad confines of its portfolio. Interested researchers should also consult the programs in Electromagnetics, Ultrashort Pulse Laser-Matter Interactions, Plasma and Electro-Energetic Physics, Biophysics, Human Performance and Biosystems, and Optoelectronics and Photonics described in the AFOSR Broad Area Announcement.

New concepts for the computational modeling of light and laser devices, including thermal and nonlinear effects, are also of interest. Combined theory, simulation, and experimental efforts designed to verify and validate innovative models are 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. Collaborative efforts with the researchers at the Air Force Research Laboratory are highly encouraged, but not required.

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A.3.e. Optoelectronics and Photonics

Program Description: This program supports Air and Space 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 nanoscale; 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 asare 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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.3.f. Plasma and Electro-Energetic Physics

Program Description: This program seeks to provide revolutionary advances in the fundamental understanding of physical processes necessary to control the interaction of electromagnetic energy and charged particles to 1) produce useful work for a variety of applications, including directed energy weapons, sensors and radar, electronic warfare, communications, and novel compact accelerators, or to 2) improve our ability to exploit and operate in a range of extreme environments and conditions. The focus of this portfolio is split between exploratory plasma physics and the basic science associated with the generation and collective interaction of electromagnetic fields and plasmas. This includes efforts directed toward an understanding of the basic principles associated with compact pulsed power, material/vacuum interfaces, and research increasing the scientific understanding required to predict energy transfer across a broad range of temporal and spatial scales. The transport of charge, energy, and information in materials interacting with plasmas and associated high-power electromagnetic field is a critical area linking topic #1 and #2 as described above.

Basic Research Objectives: Ideas for advancing the state-of-the-art in the following areas are strongly encouraged: A) strongly coupled coulomb systems including ultra-cold plasmas, novel approaches to study the physics of complex and/or dusty ionospheric plasmas, and those that address open questions regarding how plasmas involving potential states such as plasma "liquids," "glasses," and "crystals," come to equilibrium and partition their energy between various thermodynamic states; B) non-equilibrium plasmas including high energy density plasmas (i.e. plasmas far from equilibrium), certain aspects of laser plasma/matter interaction, low-temperature plasma physics, and particle-field interaction physics. Also of primary interest are proposals for basic research associated with the development of C) highly efficient solid-state or electron-beam-driven sources for high-frequency coherent radiation (high power electromagnetic [HPEM] and/or vacuum electronics), D) high-power amplifiers, E) novel sources and accelerators of particle beams, and F) compact pulsed power. New concepts for the theory, modeling, and simulation of these physical phenomena are of interest, and combined experimental/theoretical/simulation efforts that verify and validate innovative models are highly encouraged. Theory, modeling, and simulation proposals should focus on improved descriptions of physical systems of interest, physical accuracy, and complexity of simulations, and development of models to solve difficult, but realistic problems.

Proposals focusing on physical systems considered of primary interest to the portfolio will receive priority. Efforts to develop new numerical methods for difficult plasma physics problems with a focus on numerical accuracy and speed should also consult the Computational Mathematics program as described in this announcement.

Researchers should consult the program in Aerospace Materials for Extreme Environments to find the best match for research concerning materials, thermal physics and other areas of potential overlap. Although ideas relating to plasmas and electro- energetic physics in space are of interest to this program, researchers should also consult the programs in Propulsion and Power and in Space Science 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. Propagation of electromagnetic energy through, and it's interaction with, plasmas is of interest to this portfolio, however proposers should also consult the Electromagnetics program to ensure their research is considered accordingly. Nuclear batteries, nuclear fission and/or nuclear fusion for large-scale energy production are not of primary interest to this portfolio, although novel directed energy and pulsed power ideas involving nuclear reactions will be considered.

You are highly encouraged to contact the Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates

Collaborative efforts with researchers at the Air Force Research Laboratory are encouraged when appropriate, but are not required.

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A.3.g. Quantum Information Sciences

Program Description: This program encompasses fundamental experimental and theoretical research in the field of Quantum Information Science (QIS). The primary focus is on understanding, controlling, and exploiting non-classical phenomena for developing novel capabilities for the Air and Space Forces beyond those possible with classical systems in the areas including, but not limited to, networks and communications, information processing, and simulation.

Basic Research Objectives: Quantum mechanics provides the opportunity to utilize non-classical physical resources to develop beyond-classical capabilities in imaging, sensing and precision measurements, information transfer, or simulation and discovery of complex materials. Specific research topics of interest in this program include, but are not limited to, the following: quantum communications and networks, quantum repeaters, quantum information processing, and quantum simulation; and fundamental studies in support of this research area, such as fundamental investigations of the creation, manipulation, and

characterization of entanglement, highly entangled states, dissipation engineering, quantum control techniques, and coherent state transfer between different types of qubits.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.3.h. Physics of Sensing

Program Description: This portfolio seeks to understand the fundamental scientific limits of sensing and to develop revolutionary concepts for detection with improved accuracy, sensitivity, and robustness. The research spans experimental, theoretical, and computational studies. Although the principal domain of activity focuses on the electromagnetic spectrum, the areas of interest to the Air Force and Space Force are broad and include chemical and gravitational measurements. We seek to expand the basic physical understanding in propagation of electromagnetic radiation, interactions of radiation with matter, image formation, sensor tasking, data fusion, remote object detection and identification, and the effects of the atmosphere or space environment on sensing systems. Proposals are sought in all areas of ground-, air-, and space-based sensing with applications in tracking, detecting, and characterizing. Fundamental understanding which leads to development of sensors of higher sensitivity or smaller cost or form factor is of relevance. Passive and active sensing methods, particularly multimodal detection and multifunctional sensors, are of interest.

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

- Researching detection phenomena and the physics of ideal and real sensor systems including multimodal, hyperspectral, and hypertemporal, sensors.
- Discovering fundamental limits to restrictions such as limited aperture size, time of day, and imperfections in the optics, and techniques to approach or circumvent these limitations.
- Understanding irregularities in the optical path including imaging though obscured, degraded, and non-line of sight conditions and developing novel methods for imaging in these conditions.
- Creating new materials, systems, and techniques to approach the fundamental detection limits.
- Characterizing propagation of coherent and incoherent electromagnetic radiation through a turbulent atmosphere.
- Developing experimental methods and models to describe the spectral, thermal, and polarimetric signature from objects of interest.

- Understanding and predicting dynamics of space objects as it relates to identification and space domain awareness.
- Innovating techniques for on-orbit characterization, including radiation tolerant optical and non-optical sensors such as electrostatic field measurements, accelerometers and radiation dosimeters.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.3.i. 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 and Space Force space assets.

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;

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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A.3.j. Ultrashort Pulse Laser-Matter Interactions

Program Description: The Ultrashort Pulse Laser-Matter Interactions program is focused on one of 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 with matter in order to further capabilities of interest to the U.S. Air and Space Forces, 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 orders 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, which are a focus of investigation for this program. 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 electron dynamics in complex systems of interest to DOD (i.e., such as solid-state semiconductor, magnetic, and plasmonic systems). 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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, but not required.

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A.3.k. Condensed Matter Physics

Program Description: The Condensed Matter Physics program seeks to investigate modern directions in the fundamental physics of condensed matter. The ultimate goal is to lead discoveries of new states of matter and understanding of fundamental phenomena towards exploitation and engineering of electronic, magnetic and photonic properties for future disruptive capabilities that are of critical interest to the U.S. Air and Space Forces.

Basic Research Objectives: This program pursues balanced experimental and theoretical studies, aimed at discovery and understanding of new matter states and phase transitions in both equilibrium and non-equilibrium conditions, as well as understanding of their properties. The topics of interest include but are not limited to the following:

Topological phases and states: The topological states in electronic materials provide protections to physical properties, for example, conductivity and spin. The interest of this topic includes prediction and discovery of interacting topological materials, new approaches for identifying topological states and effects, and characterization and understanding of defects, e.g. dislocation, in topological phases. The prediction and realization of high temperature topological states is of particular interest.

Strongly correlated systems: Strongly correlated systems exhibit complex types of ordering and multifunctional properties arising from the subtle interplay between competing degrees of freedom in a near degenerate energy landscape. The interest of this topic includes prediction and realization of correlated electronic topological phases, control and modulation of electronic correlation in heterostructures, new theoretical approaches for strongly correlated systems, and unique methods of probing emergent phenomena associated with strong correlation.

Quantum phase transitions: Understanding quantum critical points is a stepping stone to understanding important phenomena in many condensed matter systems, such as high-temperature superconductivity, heavy fermions, and quantum magnetism. This thrust seeks experimental efforts in identifying quantum critical points, exploring phase diagrams, and probing the dynamics of physical properties near quantum critical points in model systems. Studies of physical properties (spin, charge, thermal transport), and effects of chemical doping and strain on quantum criticality are of particular interest.

This program does not focus on the synthesis or applications of high TC superconductors, metamaterials, or device physics.

You are strongly encouraged to contact our Program Officer before developing a full proposal to discuss your ideas, your proposed methods, the scope of your proposed effort, as well as the resources required in the period of three (3) to five (5) years.

DR. JIWEI LU, AFOSR/RTB1
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(703) 588-0665

A.4. CHEMISTRY AND BIOLOGICAL SCIENCES (RTB2)

The Chemistry and Biological Sciences Team is responsible for research activities in chemistry and biological sciences. A wide range of fundamental chemistry, biology, mechanics, and biophysics research is supported to provide the Air and Space Forces with novel options to increase performance and operational flexibility. Research carried out within this team will help usher in revolutionary new technologies that will fundamentally change the way future Air and Space Force weapon systems are designed and implemented.

This research effort will endeavor to identify chemical and biological mechanisms, structures, and systems with the potential to inspire future technology in all Air and Space Force systems. Understanding these mechanisms, structures and systems at a fundamental level will accelerate advances in energy technology, control of complex systems, sensors and sensory systems, and materials engineering.

The focus is on complex materials, microsystems and structures and well as systems of a biological natural by incorporating hierarchical design of mechanical and functional properties from the nanoscale through the mesoscale, ultimately leading to controlled well-understood chemistry/biochemistry, and material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. In addition to research into underlying materials/biomaterials and fundamental physical/biophysical processes, this area considers how they might be integrated into new classes of devices and pursues a fundamental understanding of materials that are not amenable to conventional computational means.

Finally, the energy extraction and storage efforts addresses the characterization, synthesis, and

utilization of fundamental energy sources, ranging from novel molecular configurations to photoelectric stimulated mitochondria and solid rocket motor propellants infused with performance improving nano-energetic particles.

The Chemistry and Biological Sciences (AFOSR/RTB2) Program Officers and topics are:

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.4.a.	Biophysics	Dr. Sofi Bin-Salamon
A.4.b.	Human Performance and Biosystems	Dr. Patrick O. Bradshaw
A.4.c.	Mechanics of Multifunctional Materials and Microsystems	Dr. Byung-Lip (Les) Lee
A.4.d.	Molecular Dynamics and Theoretical Chemistry	Dr. Michael R. Berman
A.4.e.	Natural Materials and Systems	(Acting) Dr. Patrick O. Bradshaw
A.4.f.	Organic Materials Chemistry	Dr. Kenneth C. Caster

Our research areas of interest are described in detail below:

A.4.a. 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 physics that have allowed us to unravel the complex atomic/molecular structures found in DNA and RNA. More recently areas of interest in Biophysics include, but are not limited to bio-molecular imaging while preserving structure and functionality, electromagnetic bioeffects and quantum biology. These research areas are selected for their potential to support technological advances in application areas of interest to the United States Air and Space Forces including biologically inspired new innovative and novel materials, autonomy, human performance, Directed Energy, and enhanced computational development for future Air and Space Force needs.

Basic Research Objectives: This is a 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, optics and biology by working in the sub-areas of bio-molecular imaging, electromagnetic bioeffects, and quantum biology.

New emerging scientific areas may enable precise excitation modulation of distinct atoms and molecules associated with living material to track activity of molecular processes; for controlling cellular signaling processes. Functional projections of intracellular signal pathways at the atomic/molecular level within mammalian cells, with high temporal accuracy and reversible neuromodulation are of fundamental interest in this portfolio.

Electromagnetic bioeffects associated with Directed Energy Weapons remains at the forefront of Air and Space Force science and technology interest associated with emerging new technologies, development, and deployment. The interest here is to understand fundamental atomic/molecular mechanisms associated with electromagnetic perturbation that occur below damage thresholds and may give insight into new novel means of human performance enhancement, biological control, and man machine interface. 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 results 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. 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. Proposers are welcome to explore competitive research ideas that may include collaborations in the Americas, Asia Pacific, the European Union and others.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

DR. SOFI BIN-SALAMON, AFOSR/RTB2
E-mail: biophysics@us.af.mil
(703) 696-8411

A.4.b. Human Performance and Biosystems

Program Description: The U.S. Air Force and U.S. Space Force are 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, genetic, cellular, tissue and systems changes resulting from various forms of perturbation.

Additionally, a sensory systems focus has been added to 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 3-D 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 (biological, cognitive, genetic, neural, physiological, 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. We wish to define and understand the biomarkers and genetic changes associated with human performance 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 understanding synthetic biological processes as they relate to energy production in Biosystems will be accepted. We have a specific interest in understanding organelles, cells, tissues or systems perturbed with Acoustic, Photo, Electric or Magnetic energy.

For the sensory systems portion of the portfolio a 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 3-D 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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

DR. PATRICK O. BRADSHAW, AFOSR/RTB2
E-mail: biosystems@us.af.mil
(703) 588-8492

A.4.c. Mechanics of Multifunctional Materials and Microsystems

Program Description: The main goals of this program are (a) to integrate newly emerging materials, nanoscale devices and microsystems into multifunctional structures with revolutionary impact on multiple figures of merit and thereby (b) to enable the development and production of safer, more maneuverable aerospace vehicles and platforms with unprecedented performance characteristics for Air Force and Space Force applications.

Basic Research Objectives: Specifically, the program seeks to establish the fundamental understanding required to design and manufacture new aerospace materials, nanoscale devices and microsystems for multifunctional structures and to predict their performance and integrity based on physical 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. Here structural performance means the ability to carry the mechanical load while coping with the changes in surrounding environments or operating conditions. Multifunctional design is often inspired by optimum combinations of structural and/or functional properties found in biological systems where the species survival through many evolutionary cycles has led to highly efficient designs and production of complex material systems.

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 shape, functionality and mechanical properties on demand, and (c) “self-sustaining” systems with structurally integrated power sources and self-regulating thermal management capabilities. 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 structures at multiple scales from atoms to continuum.

When subjected to a variety of multi-physics environments such as thermal, mechanical, electrical or magnetic fields, multifunctional materials will undergo complex changes in their states and physical properties. In this respect, robust multi-scale, multi-physics modeling and simulation capabilities become critical for unraveling the key scientific

underpinnings to facilitate (i) effective material design for novel multifunctionality and (ii) improved durability and reliability of structures in harsh operating environments.

Researchers are highly encouraged to contact the Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how the proposed research would advance it, the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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(703) 696-8483

A.4.d. 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
- 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 and Space 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 hyper-thermal 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 and Space 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 and Space 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.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, and the approximate cost for a three (3) to five (5) year effort, and if there are any specific submission target dates.

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(703) 696-7781

A.4.e. Natural Materials and Systems

Program Description: Materials found in nature combine many inspiring properties such as multifunctionality, self-assembly and hierarchical organization, tolerance, resilience and adaptability. Biological molecules are also interesting to explore for their exquisite sensitivity, selectivity, and energy efficiency. The vision of this program is to elucidate and use biological design principles and biological material for building novel functional materials to support AF's future missions. For example, multifunctional materials that can sense and respond while providing structural/thermal support, cell-based manufacturing platforms for on-demand material synthesis with locally-sourced starting materials.

Biological design principles may enable us to build lighter, tougher materials for extreme loading conditions or dynamically-responsive materials. The intent of this program is to

study/understand the mechanism of existing natural systems, to utilize existing biological materials, or to add new capabilities to current systems and/or materials. The research will encompass four general areas: biomaterials (non-medical only), biomolecular engineering, bio-interfacial sciences, and engineering biology for materials.

Basic Research Objectives:

The non-medical *Biomaterials* area is focused on understanding how organisms synthesize materials and control their properties. The intent is to understand the property and structure relationship within the biomaterial to enable synthetic methods to be developed or to modify existing biomaterials genetically. Natural materials can also be engineered or re-engineered through targeted chemistry (both organic and inorganic), ordering, or tailored processing to modulate material properties.

The *Biomolecular Engineering* explores strategies for building novel functional materials from biological molecules (peptides, sugars, nucleic acids, etc.). For example, some metabolites can form higher-order structures through molecular interactions not found in nature. These relatively simple and scalable building blocks may lead to development of inexpensive/ubiquitous sensors for biological or non-biological targets.

The *Bio-interfacial Sciences* area is focused on the fundamental science at the biotic and abiotic interface of a biomaterial or organism with a non-natural material such as metals and inorganics (i.e., biotemplating). Exploitation of the materials-selective binding of biomolecules is key to producing new hierarchically structured biological or bio-hybrid materials. The nanotechnology and mesotechnology sub-efforts under this area 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 electronics or three dimensional power structures. These structures could be used in the design of patterned and templated surfaces, new catalysts, and natural materials based optics/electronics (biophotonics).

Engineering Biology for Materials requires fundamental understanding to drive the development of new synthetic biology tools and parts that will function robustly and predictively in cells under various environmental conditions for materials synthesis. There are three sub-effort areas: 1) cells as factories—borrow nature's ability for self-assembly and guided assembly to have cells produce structures/materials of interest beyond small molecules. This approach offers the potential to build designed, nanostructured biomaterials with greater complexity of structure and/or function at multiple length scales; 2) cells as materials—engineered cells to interface with other biological or non-biological materials to form composites/hybrids for novel function; 3) beyond mesophiles—mechanistic understanding and harnessing of genetic parts from unusual chemistries/phenotypes found in nature, such as radiotrophy, lithotrophy, biostasis, solvent resistance, etc., and impart those phenotypes into different biosystems for materials synthesis and/or synergistic functionalities.

You are highly encouraged to contact our Program Officer prior to developing a full proposal to briefly discuss the current state-of-the-art, how your research would advance it, the approximate cost for a three (3) to five (5) year effort, and whether there are any specific submission target dates.

DR. PATRICK O. BRADSHAW, (ACTING) AFOSR/RTB2
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(703) 696-8411

A.4.f. Organic Materials Chemistry

Program Description: The goal of this research area is to achieve novel and useful properties and behaviors from polymeric and organic materials, and their organic-inorganic hybrids based on deep understanding of their chemistry, physics, and processing conditions. This understanding will lead to development of advanced organic, hybrid, and polymeric materials for future U.S. Air Force (USAF) and U.S. Space Force (USSF) applications. This program's approach is to study the chemistry and physics of these materials through synthesis and characterization, processing control, validated theoretical approaches, and establishment of structure-property relationships. Research ideas involving fundamental inorganic chemistry may be considered. While there are no restrictions on the types of properties to be investigated, there are priority areas that change. Heavy emphasis is on unconventional and novel functional properties.

This program seeks innovative, high risk, high impact fundamental materials chemistry basic research ideas that push scientific frontiers and not follow-up or extensional projects, or incremental advancements in an already on-going area. The research should be relevant in the broadest sense to the AFOSR mission to foster scientific discoveries that will ensure technological innovations and provide novel capabilities for future USAF and USSF systems to achieve global awareness, global mobility, and space operations.

Basic Research Objectives: Proposals with innovative research concepts that develop and extend fundamental understanding of material structure-property relationships, discover previously unknown properties, bring properties with active control and tunability, and/or achieve significant property improvement over current state-of-the-art materials are sought.

Current interests are in materials that emphasize novel, controllable and tunable photonic and/or electronic properties that are achieved through designing, synthesizing, and characterizing organic-based materials (i.e., small molecules, oligomers and polymers, nanostructures, and functional organic-inorganic hybrid materials).

Organic-based materials are to be a central focus of proposed research. In addition, the research may involve investigation of functional hybrid materials where the organic has been modified with an inorganic through chemical bonding, layering, or blending in a way that generates unique or significantly enhanced or tunable properties that result from synergistic interactions (i.e., the sum is greater than individual components). Fundamental inorganic chemistry is also of interest and should center on emerging areas involving synthesis and reactivity of highly novel main group, transition metal, organometallic, and cluster compounds with a focus on novel material properties or highly selective and active catalytic behavior.

Targeted synthesis of novel organic-based structures and their hybrids leading to new and unique material properties and/or enhanced multi-functionality will be considered.

Research investigations that probe reaction mechanism or theory as they relate to targeted synthesis or method development (i.e., understanding of reaction course/outcome) will also be considered. Precision synthesis of highly controlled, exact structures is desired.

Inorganic polymers that lead to unique properties are of interest in compelling cases. When done in conjunction with experiment to verify predictive capabilities, theory may be developed and/or used to probe such hybrid structures to understand their properties, and to suggest potential synthetic targets. Novel processing approaches that lead to deep, detailed understanding of property-process relationships are of interest, especially for on-demand processes (e.g., additive manufacturing). Investigation of bulk material properties (e.g., electronic, photonic, phononic) generated during such processes and understanding of their fundamental interfacial chemistry and physics is of interest.

In the area of photonics, research emphasis is on materials where refractive index can be actively tuned or controlled (e.g. third order nonlinear optical materials, electro-optic polymers, liquid crystals, photorefractive polymers, and magneto-optical polymers). In the area of electronic materials, research emphasis is on controlling properties (e.g., conductivity, charge transport and mobility, stretchable/bendable electronic materials). Controlled growth and/or self-assembly of nanostructures into well-defined structures (e.g. modified into functionally hybrids) or hierarchical and complex structures are of interest.

Research aimed at being able to control/tune two or more material properties independently through creative, precision chemistry is sought. In addition to research involving material concepts for power management, power generation, and storage applications, there are also application needs for organic materials in extreme environments (e.g., space operation).

Nanotechnology approaches are encouraged to address all the above-mentioned issues. Approaches and concepts involving excited state engineering to control the flow of energy within a material are of interest.

Research ideas are particularly encouraged that address long-standing or unanswered organic-based materials chemistry challenges that will have significant impact on advancing basic understanding behind property creation and control if successful.

You are highly encouraged to contact the Program Officer prior to developing a full proposal to understand any specific submission target dates and to submit one or more idea paragraphs (3-5 sentences plus a title and descriptive figure) that describe the essence of the idea and the fundamental science to be investigated. Alternatively, one two-page (maximum) white paper pre-proposal can be submitted that includes the objective and approach of the proposed effort, research aims with the current state-of-the-art, a brief rationale why the approach can achieve the goals, the anticipated outcomes if the research is successful; a third page can contain two or three key references and a one sentence budget detailing the approximate yearly cost for a three (3) to five (5) year effort.

DR. KENNETH C. CASTER, AFOSR/RTB2
Email: organic@us.af.mil
(703) 588-8487

A.5. AFOSR INTERNATIONAL OFFICES (IO)

Program Description: AFOSR has international program offices in London, Tokyo, and Santiago. International Program Officers (IPOs) at these offices fund basic research grants at foreign institutions across Europe, Africa, Asia, Australia and Central and South America. Research areas of interest include all listed topics for the four scientific teams given above as

well as other innovative research concepts listed below in section A.6.

Foreign Principal Investigators are highly encouraged to contact the international program office in their region prior to developing a full proposal, preferably by email, to discuss the current state of the art in his/her area of interest, how the proposed research would advance current understanding, the approximate cost of an initial effort, and if there are target submission dates.

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.5.a.	European Office of Aerospace Research and Development	Dr. Barrett Flake
A.5.b.	Asian Office of Aerospace Research and Development	Dr. Jeremy Knopp
A.5.c.	Southern Office of Aerospace Research and Development	Dr. Daniel Montes

A.5.a. European Office of Aerospace Research and Development (EOARD), London, United Kingdom

For enquiries, email eoard.orgbox@us.af.mil

A.5.b. Asian Office of Aerospace Research and Development (AOARD), Tokyo, Japan

For enquiries, email afosr.aoard@us.af.mil

A.5.c. Southern Office of Aerospace Research and Development (SOARD), Santiago, Chile

For enquiries, email CienciaAmericaLatina@state.gov or LatinAmericaScience@state.gov

A.6. OTHER INNOVATIVE RESEARCH CONCEPTS

Program Description: We are always looking for new basic research ideas and are open to considering unique and revolutionary concepts which do not fall into the portfolios described above. 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. Research should investigate truly new and unique approaches and techniques that may enable revolutionary concepts with potentially high-payoff relevant to Air and Space Forces. Pre-coordination with the points of contact listed below is, however, very strongly encouraged before submitting a proposal.

DR. VAN BLACKWOOD, AFOSR/RT
E-mail: specialtopic1@us.af.mil
(703) 696-1141

A.7. INTERNATIONAL STUDENT EXCHANGE PROGRAM (ISEP)

Program Description: The International Student Exchange Program is an opportunity for the

AFOSR Program Officers to give a funded Principal Investigator's (PI) graduate student the opportunity to work with an overseas collaborator for a short term, or the opportunity for an overseas collaborator to send their graduate student to work with the AFOSR funded PI here for a short term. For approval of use of the ISEP, it would have to enhance the grant with something like unique equipment access, sharing/learning new techniques, etc. which could further enable significant advances towards Air Force and Space Force Science & Technology (AF S&T) objectives and could further help identify advances in emerging opportunities within the international scientific community. This program could also further assist AFOSR leadership a means to evaluate highly promising new international research, and direct additional funding towards areas of strategic Air Force and Space Force importance.

If your future grant might benefit from additional funding from this program, it would be prudent to indicate so in your grant proposal by identifying them as individual funding options for each funded year. Applications to supplement an existing project with this additional funding may be considered on a case-by-case basis post-award as individual options for each funded year.

We anticipate not more than $15,000 in additional funding per year, and any overhead or administrative costs will impact the ability to maximize the exchange collaboration.

Such charges will be evaluated in determining project feasibility. The $15,000 in additional funding will not be further supplemented to compensate for overhead and administrative costs.

If you intend to utilize this opportunity, your proposal must include details on how the collaborative effort will benefit your research, enable significant advances toward Air Force and Space Force science and technology objectives, and/or identify advances in emerging opportunities (e.g., provide access to unique equipment, share new technologies, or identify potential new international research opportunities). Also, a separate budget and budget justification must be provided.

The exchange proposal is considered an optional funding item and must be self- contained and stand on its own in the event the government chooses not to fund the exchange program element of your proposal.

Your supplemental student exchange program funding request will be evaluated using the section E.1. Criteria for proposals submitted under this announcement.

We reserve the right to request proposals on previously awarded grants and cooperative agreements, subject to funds availability and agency approval of the proposal. These additional funding proposals will be evaluated on a case-by-case basis using the evaluation and selection criteria from the broad agency announcement associated with that award, and the benefit it provides as stated above.

B. FEDERAL AWARD INFORMATION

Approximately $200 million is anticipated to be available for support of actions awarded under this announcement, subject to availability of funds. Research proposals funded between $100,000 and $300,000 per year are encouraged. Most of our awards are three (3) years in duration. Awards may be proposed for not more than five (5) years.

All applications received under this announcement will be considered applications for new awards, including any application marked renewal. Applications to supplement an existing project with additional funding may be considered on a case-by-case basis post-award, but are not anticipated to compete with new award funding.

Awards may start any time during the year. The actual start date is determined at the time of award, and may be different than the date you propose. We discuss this more in section F. Federal Award Administration Information.

- Awards are made under the authority of 10 U.S.C. 2358 in the form of grants, cooperative agreements, or contracts. We rely on discretionary appropriated funds for this program. We can only make awards if enough funds are made available. We select what kind of award instrument we can use based on requirements in the Federal Grant and Cooperative Agreement Act 31 U.S.C. 6301 – 31 U.S.C. 6308. Awards may take the form of contracts, grants, cooperative agreements, technology investment agreements and other transaction agreements as appropriate. The following provides a brief description of potential instrument types:
    - Grant. A legal instrument consistent with 31 U.S.C. 6304, is used to enter into a relationship:
    - The principal purpose of which is to transfer a thing of value to the recipient to carry out a public purpose of support of stimulation authorized by a law or the United States, rather than acquire property or services for the Federal Government's direct benefit or use.
    - In which substantial involvement is not expected between the Federal Government and the recipient when carrying out the activity contemplated by the grant.
- No fee of profit is allowed.
- Cooperative Agreement. A legal instrument which, consistent with 31 U.S.C 6305, is used to enter into the same kind of relationship as a grant, except that substantial involvement is expected between the Federal Government and the recipient when carrying out the activity contemplated by the cooperative agreement. No fee or profit is allowed.
- Technology Investment Agreement (TIA). Assistance Transaction other than a Grant or a Cooperative Agreement (see 32 CFR Part 37). A legal instrument, consistent with 10 U.S.C. 2371, which may be used when the use of a contract, grant, or cooperative agreement is not feasible or appropriate for basic, applied, and advanced research projects. The research covered under a TIA shall not be duplicative of research being conducted under an existing DoD program. To the maximum extent practicable, TIAs shall provide for at least a 50/50 cost share between the Government and the applicant. An applicant's cost share may take the form of cash, independent research and development (IR&D), foregone intellectual property rights, equipment, access to unique facilities, and/or other means. Due to the extent of cost share, and the fact that a TIA does not qualify as a "funding agreement" as defined at 37 CFR 401.2(a), the intellectual property provisions of a TIA can be negotiated to provide expanded protection to an applicant's intellectual property. No fee or profit is allowed on TIAs.
- Other Transaction for Prototype (OTA). A legal instrument, consistent with 10 U.S.C. 2371,

which may be used when the use of a contract, grant, or cooperative agreement is not feasible or appropriate for prototype projects directly relevant to enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or materials proposed to be acquired or developed by the Department of Defense, or for improvement of platforms, systems, components, or materials in use by the armed forces. The effort covered under an OTA shall not be duplicative of effort being conducted under an existing DoD program (please refer to the DoD Other Transactions Guide for Prototype Projects dated November 2018). This document along with other OTA resources may be accessed at the following link: http://www.acq.osd.mil/dpap/cpic/cp/10USC2371bOTs.html

We reserve the right to select and fund for award all, some, part, or none of the proposals received in response to this announcement. There is no guarantee of an award.

C. ELIGIBILITY INFORMATION

C.1. ELIGIBLE APPLICANTS

C.1.a. General

All qualified, responsible organizational applicants from academia, the non-profit sector, and industry are eligible to submit research proposals. This includes University Affiliated Research Centers unless precluded from submitting a proposal by their Department of Defense operating contract.

C.1.b. HBCU/MI, Tribal College and University, and Small Business Applicants Encouraged

Historically Black Colleges and Universities and Minority institutions (HBCU/MI), Tribal Colleges and Universities, and HBCU/MI affiliated medical centers are encouraged to submit research proposals and join others in submitting proposals. Small business concerns are also encouraged to submit proposals and join others in submitting proposals. However, no funds under this announcement are reserved or otherwise set-aside for any specific entity type.

C.1.c. Eligibility Notice for All Applicants

We review your application, proposal, and Office of Management and Budget (OMB) designated repositories of government-wide public and non-public data, including comments you have made, as required by 31 U.S.C. 3321 and 41 U.S.C. 2313 and described in 2 CFR 200.205 and 32 CFR 22.410 to assess risk posed by applicants, and confirm applicants are qualified, responsible, and eligible to receive an award. If we cannot determine you or your organization qualified and responsible, you are not eligible to receive an award.

C.1.d. Ineligible Entities

None of the following entity types are eligible to submit proposals as primary award recipients under this announcement.

- Federally Funded Research and Development Centers (FFRDCs)
- Individual persons or people
- Federal agencies

C.2. COST SHARING

We do not require cost sharing for proposals under this announcement (except as may be required for transactions other than contracts, grants, and cooperative agreements entered into under 10 U.S.C. 2371). Cost sharing is not an evaluation or selection criterion.

C.3. OTHER

C.3.a. Acknowledgement of Support and Disclaimer Requirements

You must include the F.3.d. Acknowledgement of Research Support on all materials created or produced under our awards.

You must include the F.3.e. Disclaimer Language on materials as required.

Our award document may provide additional instructions about specific distribution statements to use when you provide research materials to us. You are not eligible to submit a proposal if you cannot accept these terms.

C.3.b. Expectation of Public Dissemination of Research Results

We expect research funded by this announcement will be fundamental. We expect public dissemination of research results if you receive an award. This is a basic requirement for unclassified research results.

We intend, to the fullest extent possible, to make available to the public all unclassified, unlimited peer-reviewed scholarly publications and digitally formatted scientific data arising from research and programs funded wholly or in part by the DoD as described in the OUSD, AT&L Memorandum, "Public Access to Department of Defense-Funded Research" dated 09 Jul 2014.

We follow DoD Instruction 5230.24 and DoD Instruction 5230.27 policies and procedures to ensure broad dissemination of unclassified research results to the public and within the Government. The DoD Instruction 5230.27 policy and procedures allowing publication and public presentation of unclassified fundamental research results will apply to all research proposed under this competition unless the Program Officer gives you an explicit, written exclusion to these policies with the Grants or Contracting Officer's advice and consent. All exclusions must be authorized or required by law, and must cite a valid legal authority.

You must provide a copy of all peer-reviewed publications developed or produced from research conducted with Air Force and Space Force funds to our Program Officer.

You are not eligible to submit a proposal if you cannot accept these terms.

C.3.c. Conflict of Interest

(1) General Requirement for Disclosure

You and your organization must disclose any potential or actual scientific or non-scientific conflict of interest(s) to us. You must also disclose any potential or actual conflict(s) of interest for any subrecipient you include in your proposal.

You must provide enough information for us to evaluate your disclosure. We may have to ask you more questions if we need more information.

At our discretion, we may ask you for a conflict of interest mitigation plan after you submit your proposal. Your plan is subject to our approval.

(2) Scientific Conflict of Interest

Scientific collaborations on research and development projects are generally the result of close collaboration prior to the submission of applications for support. Accordingly, virtually all of these collaborations might be considered to include a potential conflict of interest. The potential conflict is mitigated by the disclosure of these collaborations, and the list of current and pending support you provide for senior and key researchers.

D. APPLICATION AND SUBMISSIONINFORMATION

D.1. ADDRESS TO REQUEST APPLICATION PACKAGE

All the application forms you need are available electronically on Grants.gov. From the "View Grant Opportunity" page, you can click on the "Package" tab to download the application package.

You can find the electronic application package on Grants.gov by searching for the announcement number shown on page one We will not issue paper copies of this announcement.

Please contact us at afosr.baa@us.af.mil to request a reasonable accommodation for any accessibility requirements you may have.

D.2. CONTENT AND FORM OFAPPLICATION SUBMISSION

D.2.a. Pre-proposal Inquiries and Questions

If you need help with technical matters, you should email the individual listed for your topic of interest in section A. Program Description. We provide a list of all the programs and Program Officers listed in this announcement again in section G.1. Technical Inquires and Questions.

If you have general questions about this announcement or administrative matters, you must submit your question in writing by email to the contact listed in section G.2. General Inquiries and Questions.

The Program Officer does not have the authority to make commitments for us. Grants and Contracting Officers acting within their warranted capacity are the only people authorized to make commitments for the Government.

D.2.b. The Application as a Whole

You must submit your proposal electronically through Grants.gov. We will not accept or evaluate any proposal submitted by any means other than through Grants.gov.

You must use the electronic Standard Form (SF) 424

Research and Related (R&R) Form Family, OMB Number 4040-0001. The SF 424 (R&R) Application for Federal assistance form must be your cover page. No pages may precede the SF 424 (R&R).

You may submit a proposal for one or more topics, or for a specific portion of a topic. You may submit different proposals on any number of topics, or different proposals on the same topic. We may not make awards in every topic area.

You must mark your application with the announcement number.

A summary of what is required for a complete proposal is summarized below:

- We require the forms and attachments in bold text with all applications
- Some applications require the attachments in italic
- We provide more instructions in D.3. Component Pieces of the Application

R&R FORM, OMB No. 4040-0001	FIELD	ATTACHMENT
SF 424 (R&R) Application for Federal Assistance, including an authorized signature	**18.**	**Certification Regarding Lobbying Form or** SF-LLL Disclosure of Lobbying Activities Per instructions in D.4
R&R Other Project Information Form	**7.**	**Project Summary / Abstract**
	8.	**Project Narrative**
	9.	**Bibliography & References Cited**
	10.	*Facilities and Other Resources*
	11.	*Equipment*
	12.	*Other Attachments*
R&R Senior / Key Person Profile Form (Expanded)		**Biographical Sketch**
		Current & Pending Support
R&R Personal Data Form		**None**
R&R Budget Form		**Budget Justification**
R&R Subaward Budget Attachments Form		*Subaward Budget*
R&R Project / Performance Site Locations Form		**None**

The SF 424 (R&R) must include the signature of an authorized representative from your organization. The signature is affixed electronically by Grants.gov upon submission. You are still required to submit any documentation, including disclosure of any unpaid delinquent tax liability or a felony conviction under any Federal law (see FAR 52.209-11).

This signature is considered the signature for the application as a whole.

D.2.c. Proposal Format

i. Paper Size – 8.5 x 11-inch paper

ii. Margins – 1 inch

iii. Spacing – Single, 1.5, or 2.0-line spacing

iv. Font – Times New Roman or Garamond, 10, 11, or 12point

v. Page Limitation – None. However, unnecessarily elaborate or lengthy proposals are not desirable

vi. Attachments – Electronic Portable Document Format(PDF)

vii. Content – As described below

D.2.d. Proposal Length

We do not limit the length of your proposal for this competition; however, you must not include elaborate brochures, reprints, or presentations beyond those sufficient topresent a complete and effective proposal.

D.2.e. Marking Requirements for Confidential or Proprietary Information

You must mark your proposal and any proposal sections that contain proprietary or confidential information. You must use the protective legend found at FAR 52.215- 1(e) Instructions to Offerors -- Competitive Acquisition (Jan 2017) modified to permit release to our outside evaluators.

We make every effort to protect the confidentiality of proposals, including any proposal evaluations; however, under Freedom of Information Act (FOIA) requirements, some or all proposal information may be subject to release.

Your entire proposal, or any portions thereof, without protective markings or otherwise identified as requiring protection will be considered voluntarily furnished to us without restriction, and will be treated as such for all purposes.

D.2.f. Electronic Form and Proposal Attachments

Your application and proposal attachments must be in electronic file formats. You should use the Portable Document Format (PDF) for your attachments. DO NOT password protect any attachments. The website http://www.grants.gov/web/grants/applicants/adobe-software-compatibility.html provides additional important instructions.

D.3. GRANTS.GOV APPLICATION SUBMISSION AND RECEIPT PROCEDURES

This section provides the application submission and receipt instructions for AFOSR program applications. Please read the following instructions carefully and completely.

D.3.a. Electronic Delivery

AFOSR is participating in the Grants.gov initiative to provide the grant community with a single site to find and apply for grant funding opportunities. AFOSR encourages applicants to submit their applications online through Grants.gov.

D.3.b. How to Register to Apply through Grants.gov

Instructions: Read the instructions below about registering to apply for AFOSR funds. Applicants should read the registration instructions carefully and prepare the information requested before beginning the registration process. Reviewing and assembling the required information before beginning the registration process will alleviate last-minute searches for required information.

The registration process can take up to four weeks to complete. Therefore, registration should be done in sufficient time to ensure it does not impact your ability to meet required application submission deadlines.

If individual applicants are eligible to apply for this grant funding opportunity, refer to: https://www.grants.gov/web/grants/applicants/individual-registration.html

Organization applicants can find complete instructions here: https://www.grants.gov/web/grants/applicants/organization-registration.html

1) *Obtain a DUNS/UEI Number*: All entities applying for funding, including renewal funding, must have a Data Universal Numbering System (DUNS) number from Dun & Bradstreet (D&B). Applicants must enter the DUNS number in the data entry field labeled "Organizational DUNS" on the SF-424 form. Transition to the Unique Entity Identifier (UEI) from DUNS is underway; grants.gov has deployed forms compatible with the UEI. In April 2022, DUNS numbers will no longer be used, the UEI is required.

   For more detailed instructions for obtaining a DUNS number, refer to: https://www.grants.gov/web/grants/applicants/organization-registration/step-1-obtain-duns- number.html

   By April of 2022, the federal government will stop using the DUNS number to uniquely identify entities registered in the System for Award Management (SAM). At that point, entities doing business with the federal government will use a Unique Entity Identifier (UEI) created in SAM.gov. They will no longer have to go to a third-party website to obtain their identifier. Active registrants will have their UEI assigned and viewable within SAM.gov; there is no action for registered entities to take at this time.

   This transition allows Federal Agencies to streamline the entity identification and validation process, making it easier and less burdensome for entities to do business with the federal government.

   For more detailed instructions for obtaining a UEI number, refer to: https://sam.gov/content/entity-registration

2) *Register with SAM*: In addition to having a DUNS/UEI number, organizations applying online through Grants.gov must register with the System for Award Management (SAM). All organizations must register with SAM in order to apply online. Failure to register with SAM will prevent your organization from applying through Grants.gov.

   For more detailed instructions for registering with SAM, refer to: https://www.grants.gov/web/grants/applicants/organization-registration/step-2-register-with- sam.html.

3) *Create a Grants.gov Account*: The next step in the registration process is to create an account with Grants.gov. Applicants must know their organization's DUNS/UEI number to complete this process. Completing this process automatically triggers an email request for applicant roles to the organization's E-Business Point of Contact (EBiz POC) for review. The EBiz POC is a representative from your organization who is the contact listed for SAM. To apply for grants on behalf of your organization, you will need the Authorized Organizational Representative (AOR) role.

   For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.grants.gov/web/grants/applicants/organization-registration/step-3-username- password.html

4) *Authorize Grants.gov Roles*: After creating an account on Grants.gov, the EBiz POC receives an email notifying them of your registration and request for roles. The EBiz POC will then log in to Grants.gov and authorize the appropriate roles, which may include the AOR role, thereby giving you permission to complete and submit applications on behalf of the organization. You will be able to submit your application online any time after you have been approved as an AOR.

   For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.grants.gov/web/grants/applicants/organization-registration/step-4-aor-authorization.html

5) *Track Role Status*: To track your role request, refer to: https://www.grants.gov/web/grants/applicants/organization-registration/step-5-track-aor- status.html

6) *Electronic Signature*: When applications are submitted through Grants.gov, the name of the organization's AOR that submitted the application is inserted into the signature line of the application, serving as the electronic signature. The EBiz POC **must** authorize individuals who are able to make legally binding commitments on behalf of the organization as an AOR; **this step is often missed and it is crucial for valid and timely submissions.**

D.3.c. How to Submit an Application to AFOSR via Grants.gov

Grants.gov applicants can apply online using Workspace. Workspace is a shared, online environment where members of a grant team may simultaneously access and edit different web forms within an application. For each funding opportunity announcement (FOA), you can create individual instances of a workspace.

Below is an overview of applying on Grants.gov. For access to complete instructions on how to apply for opportunities, refer to:

https://www.grants.gov/web/grants/applicants/apply-for-grants.html

Create a Workspace

Creating a workspace allows you to complete it online and route it through your organization for review before submitting.

Complete a Workspace

Add participants to the workspace, complete all the required forms, and check for errors before submission.

- Adobe Reader: If you decide not to apply by filling out web forms you can download individual PDF forms in Workspace so that they will appear similar to other Standard or administering agency forms. The individual PDF forms can be downloaded and saved to your local device storage, network drive(s), or external drives, then accessed through Adobe Reader.

  NOTE: Visit the Adobe Software Compatibility page on Grants.gov to download the appropriate version of the software at: https://www.grants.gov/web/grants/applicants/adobe-software-compatibility.html

- Mandatory Fields in Forms: In the forms, you will note fields marked with an asterisk and a different background color. These fields are mandatory fields that must be completed to successfully submit your application.

- Complete SF-424 Fields First: The forms are designed to fill in common required fields across other forms, such as the applicant name, address, and DUNS/UEI number. To trigger this feature, an applicant must complete the SF-424 information first. Once it is completed, the information will transfer to the other forms.

Submit a Workspace

An application may be submitted through workspace by clicking the Sign and Submit button on the Manage Workspace page, under the Forms tab. Grants.gov recommends submitting your application package at least 24-48 hours prior to the close date to provide you with time to correct any potential technical issues that may disrupt the application submission.

Track a Workspace

After successfully submitting a workspace package, a Grants.gov Tracking Number (GRANTXXXXXXXX) is automatically assigned to the package. The number will be listed on the Confirmation page that is generated after submission.

For additional training resources, including video tutorials, refer to: https://www.grants.gov/web/grants/applicants/applicant-training.html

Applicant Support: Grants.gov provides applicants 24/7 support via the toll-free number 1- 800-518-4726 and email at support@grants.gov. For questions related to the specific grant opportunity, contact the number listed in the application package of the grant you are applying for.

If you are experiencing difficulties with your submission, it is best to call the Grants.gov Support Center and get a ticket number. The Support Center ticket number will assist the administering agency with tracking your issue and understanding background information on the issue.

D.4. COMPONENT PIECES OF THE APPLICATION

D.4.a. SF 424 (R&R) Application for Federal Assistance Form

The SF 424 (R&R) Application for Federal assistance form must be your cover page. No pages may precede the SF 424 (R&R).

Complete all required fields in accordance with the "pop-up" instructions on the SF 424 (R&R) form. The completion of most fields is self-explanatory. You can turn on Grants.gov "Help Mode" to provide additional instructions for forms. "Help Mode" is turned on by the icon with the pointer and question mark at the top of the form.

We have special instructions for completion of several SF 424 (R&R) form fields in your application.

Our instructions are:

FIELD	INSTRUCTION
2.	You may leave "Applicant Identifier" blank
3.	You may leave "Date Received by State" and "State Application Identifier" blank
9.	You must list Air Force Office of Scientific Research as the Federal Agency if Grants.gov has not pre-populated this answer
16.	You should check "No." and "Program is Not Covered by Executive Order 12372"
17.	Select "I Agree" to: Certify that all statements in the proposal, your, and Internal Confidentiality Agreements are true, complete, and accurate to the best of your knowledge. *See section F.3. Administrative and National Policy Requirements for more information and links to the full text of these items.*
18.	You will have to attach the completed the D.4.c. Certification Regarding Lobbying Form if your grant amount exceeds $100,000 and if you do not have lobbying activity to disclose. If you do have lobbying activity to disclose, you will have to attach the completed D.4.b. SF-LLL Disclosure of Lobbying Activities.

D.4.b. SF-LLL Disclosure of Lobbying Activities Form

When required, attach this disclosure to field 18 of the R&R Other Project Information Form.

If you have lobbying activity that you must disclose under 31 U.S.C. 1352 as implemented by the DoD in 32 CFR Part 28, you must attach the completed SF-LLL Disclosure of Lobbying Activities. You can find instructions for completing this form at

http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf.

D.4.c. Certification Regarding Lobbying Form

When required, attach this certification to field 18 of the R&R Other Project Information Form.

Grant awards require a certification of compliance with a national policy mandate concerning lobbying. Grant applicants shall provide this certification by electronic submission of SF424 (R&R) as a part of the electronic proposal. The lobbying form

must be submitted with all proposals exceeding $100,000 in total funding.

D.4.d. R&R Other Project Information Form

Complete this form as indicated. You must include all necessary attachments.

FIELD	INSTRUCTION
1, 1a.	You must address all prospective human subject involvement by answering these questions. Additional documentation pursuant to National Policy and U.S. Air Force and Space Force standards is required for all proposals with human use research or involvement.
2, 2a.	You must address all prospective animal research and/or recombinant deoxyribonucleic acid (rDNA) involvement by answering these questions. Additional documentation pursuant to National Policy and U.S. Air Force standards is required for all proposals with animal or rDNA research or involvement.
4a.	For any proposal that has an actual or potential impact on the environment, answer yes and provide the answers and attachments required for fields 4b, 4c, and 4d. Additional documentation in accordance with National Policy and U.S. Air Force and Space Force standards is required for any proposal with an actual or potential impact on the environment.
7.	Attach your D.4.e. Publicly Releasable Abstract
8.	Attach your D.4.f. Project Narrative
9.	Attach your D.4.g. Bibliography and References Cited
10.	Attach a Facilities and Other Resources description document here if you need to supplement your D.4.f. Proposal Narrative facilities and resources section.
11.	You may supplement your D.4.j. Budget Justification by attaching an Equipment Justification here. Do not duplicate information included on your budget justification. If you attach an Equipment Justification, make sure you reference the attachment in your budget justification.
12.	Attach the D.4.k R&R Subaward Budget Attachments Form if applicable and not attached elsewhere. You should have budgets for all subawards proposed attached within this form before attachment. Attach all D.4.l Subaward Budget Justifications as applicable Attach your D.4.n Data Management Plan here if applicable

D.4.e. Publicly Releasable Project Summary / Abstract

You must attach the Project Summary / Abstract to field 7 of the R&R Other Project Information form.

You must submit the "AFOSR Abstract" an attachment with the proposal submission, this form's located on the "Related Documents" tab of grants.gov. You must provide a concise abstract of 300 words or less with your proposal (no more than 2000 characters). You must mark this abstract publically releasable. Your abstract should use terms the public can understand to describe the research objective, technical approach, anticipated outcome, and potential impact of the specific research.

Your abstract header should include the ***Program Officer's name and office symbol*** from section G.1. Technical Inquiries and Questions below.

If you receive an award, we must publish your abstract to a searchable website available to the general public in accordance with Public Law 113-235. The website address is https://dodgrantawards.dtic.mil/grants/#/home.

D.4.f. Project Narrative

You must attach the Project Narrative to field 8 of the R&R Other Project Information Form. The narrative must be complete and self-contained to qualify for review.

You must clearly describe your research, including your research objective and approach. Your project narrative will be evaluated using the section E.1. Criteria. You should show strength in as many of the evaluation and selection areas as practicable to demonstrate maximum competitiveness.

You must describe any environmental impacts of your research outside the laboratory in any appropriate narrative section, including how you will ensure compliance with environmental statutes and regulations.

Your narrative should include the following elements:

(1) Statement of Objectives

You must summarize your proposed research on a single page titled "Statement of Objectives." We may decide to incorporate your statement of objectives into the award as a description of the work instead of incorporating the whole technical proposal.

You should use active verbs when you prepare the statement of objectives, e.g., "conduct" research in a subject area, "investigate" a problem, "determine" to test a hypothesis.

(2) Research Effort

(a) You should describe the research you plan in detail. State the research objectives and approach, and the relationship and comparable objectives to research progress elsewhere. Describe your research team's knowledge in the field, and provide a bibliography and list of literature citations. Discuss the nature of the expected results.

(b) The adequacy of this information will influence the overall evaluation in accordance with the criteria and procedures specified in section E. Application

Review Information below.

(3) Principal Investigator (PI) and Senior Personnel Time

(a) You must provide estimate of time the principal investigator and other senior professional personnel will devote to the research. Your estimate must include information pertaining to the proportion of time anticipated devoted to this research, to other research, and to other commitments of time such as sabbatical, extended leave, and teaching duties.

(b) State the number of graduate students for whom each senior staff member is responsible.

(c) If your principal investigator or other key personnel have current, pending, or expected research supported by other sponsors or agencies during the period you seek our 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.

You must attach a list of Current and Pending Support for each person listed on the D.4.o. R&R Senior / Key Person Profile (Expanded) Form. Each abstract should include research title, objectives, approach, and budget for both present and pending research projects. Send any changes as they become known.

(4) Your Facilities

(a) Describe the facilities available for performing the proposed research, and any additional facilities or equipment the organization proposes to acquire at its own expense for the work.

(b) Indicate any government-owned facilities that will be used. Indicate any government-owned equipment possessed presently that will be used. The facilities contract number, or in absence of a facilities contract, the specifics of the facilities or equipment, and the number of the award under which they are accountable are required.

(c) Government Furnished Equipment

You may list any special Government-owned property or test equipment required to complete the research. When possible and practicable, give a description or title for each item, the current location, and an estimated cost as applicable. If you do not have information about individual items, group items you require by class and provide an estimate of values.

(5) High Performance Computing Requirements

You may be eligible to use DoD high performance computing resources at no cost to your research. You should address utilization of this program if you need high performance computing cycles to meet the needs of your research. This program provides access to a range of state-of-the-art high performance computing assets and user training opportunities that can be used in some of our awards; special terms and conditions apply. You can review the details, capabilities, and requirements of the program at www.hpc.mil.

Our Program Officers will help you establish an account if your proposal is selected

for an award, and can answer questions before you submit your proposal.

D.4.g. Bibliography and References Cited

You must attach your narrative Bibliography and References to field 9 of the R&R Other Project Information Form.

D.4.h. R&R Senior/Key Person Profile (Expanded) Form

You must attach a short biographical sketch and list of significant publications (vitae) for each Senior/Key Person. You must also attach a list of current and pending support as discussed in Principal Investigator (PI) and Senior Personnel Time.

You must list all key persons proposed for the research on the R&R Senior/Key Person Profile (Expanded) Form. Key persons are generally the PI, any Co-PIs, and senior staff. We use this information to evaluate the qualifications of you and your research team.

To evaluate compliance with Title IX of the Education Amendments of 1972 (20 U.S.C. A subsection 1681 Et. Seq.), the DoD is collecting certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in STEM disciplines. To enable this assessment, each applicant must include this form completed as indicated.

The Degree Type and Degree Year Fields will be used by DoD as the source for career information. In addition to the required fields on the form, applicants must complete these two fields for all individuals that are identified as having the project role of PD/PI or Co-PD/PI on the form. Additional senior/key persons can be added by selecting the "Next Person" button.

D.4.i. R&R Budget Form

You must provide all information requested. You must estimate the total research project cost. You must categorize funds by year and provide separate annual budgets for projects lasting more than one year. A budget justification must be included.

You must include enough budget related information in your proposal to support your costs as reasonable and realistic, and in compliance with 2 CFR 200 Subpart E - Cost Principles.

Not having enough information in your proposal to understand if your costs are reasonable and realistic is the most common reason awards are delayed.

D.4.j. Budget Justification

You must provide a detailed budget justification for each year that clearly explains the need for each item.

The entire budget justification and supporting documentation must be combined into a single file and attached to field L of the R&R Budget Form. The budget narrative submitted with the application must match the dollar amounts on all required forms. Please explain each calculation and provide a narrative that supports each budget category. This detailed budget justification must match the proposed budget categories. Each year of the budget justification narrative must stand alone; lump sum budget justifications are not

allowed. If options are proposed, option detailed budget justifications must stand alone as well, no lump sum justifications allowed.

(1) You must itemize travel. Estimate the cost and purpose of each trip proposed, the number of trips, the number of travelers, the destination, the duration, and the basis for calculating costs such as airlines and hotels.

Below is a sample of the travel portion:

TRAVEL	Unit	Trips	Travelers	Nights	Days	Unit Cost	Total Travel
Airfare	roundtrip	1	1			$900.00	$900.00
Lodging	day	1	1	3		$75.00	$225.00
Per Diem	day	1	1		3	$40.00	$120.00
Automobile Rental	day	1	1		3	$45.00	$135.00
Subtotal Travel		**4**	**4**	**3**		**$1,060**	**$1,380.00**

(2) You must itemize materials/supplies. List all material/equipment by type and kind with associated costs. Indicate what your costs are based on, such as vendor quotes, historical data and/or engineering estimates. **You should include vendor quotes and/or catalog pricing data**.

(3) Proposals including request to purchase **equipment** must include equipment quotes or vendor agreements. "Equipment" is nonexpendable, tangible personal property with a unit cost of $5,000 or more having a useful life of more than 1 year, unless determined otherwise by recipient's internal policy. Items that do not meet the "equipment" definition can be included under supplies. List each piece of equipment to be purchased and provide description of how it will be used in the project.
Budget narrative should explain why the equipment is necessary for successful completion of the project. Provide quotes in English Language (US Dollars) if available, or indicate the basis of equipment cost. If you have any subaward(s), you should describe how you determined subaward costs were determined fair and reasonable. Your business office usually makes this determination.

(4) **DHHS/ONR Rate Agreement:** If you use a Government rate agreement to propose indirect cost rates and/or fringe benefit rates, you must attach a signed DHHS or ONR copy of the agreement youused to not delay the negotiation process.

(5) Helpful Cost Principle Reference Information

(a) Grant Applicants

(i) 2 CFR 200, Subpart E – Cost Principles

(ii) General Provisions for Selected Items of Cost in 2 CFR 200.420 through 2 CFR 200.475

(b) Contract Applicants

(i) FAR Part 31 Contract Cost Principles and Procedures

(ii) FAR 31.205 Selected Costs

(iii) FAR Subpart 30.2 CAS Program Requirements if your organization does not have an exemption to CAS as described in FAR 9903.201-1 CAS applicability

D.4.k. R&R Subaward Budget Attachments Form

You must attach all subaward budgets to field 12 of the R&R Other Project Information Form.

You must provide a budget at the same level of detail as your D.3.i. Prime budget for each proposed subaward. A subaward budget justification must be attached.

D.4.l. Subaward Budget Justification

You must attach all subaward budget justifications to field 12 of the R&R Other Project Information Form.

You must provide a subaward budget justification at the same level of detail as your

D.3.j. prime budget justification for each proposed subaward.

D.4.m. R&R Project / Performance Site Locations Form

You must complete all information as requested. You must include the ZIP+4 for each performance location you list.

D.4.n. Data Management Plan (Optional)

You can decide if you want to include a Data Management Plan with your application. If you do, attach your Data Management Plan to field 12 of the R&R Other Project Information Form.

Your "Data Management Plan" should be two (2) pages or less in length and discuss:

a. The types of data, software, and other materials to be produced in the course of the project, and include a notation marking items that are publicly releasable;

b. How the data will be acquired;

c. Time and location of data acquisition if they are scientifically pertinent;

d. How the data will be processed;

e. The file formats and the naming conventions that will be used;

f. A description of the quality assurance and quality control measures during collection, analysis, and processing;

g. If existing data are to be used, a description of their origins;

h. A description of the standards to be used for data and metadata format and content;

i. Plans and justifications for archiving the data;

j. The timeframe for preservation; and

k. If for legitimate reasons the data cannot be preserved, the plan must include a justification citing such reasons.

D.4.o. R&R Personal Data Form

To evaluate compliance with Title IX of the Education Amendments of 1972 (20 U.S.C. A subsection 1681 Et. Seq.), The DoD is collecting certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in STEM disciplines. To enable this assessment, each applicant must include this form completed as indicated.

This form will be used by DoD as the source of demographic information, such as gender, race, ethnicity, and disability information for the Project Director/Principal Investigator and all other persons identified as Co-Project Director(s)/Co-Principal Investigator(s). Each application must include this form with the name fields of the Project Director/Principal Investigator and any Co-Project Director(s)/Co-Principal Investigator(s) completed; however, provisions of the demographic information in the form is voluntary. If completing the form for multiple individuals, each Co-Project Director/Co-Principal Investigator can be added by selecting the "Next Person" button. The demographic information, if provided, will be used for statistical purposes only and will not be made available to merit reviewers. Applicants who do not wish to provide some or all of this information should check or select the "Do not wish to provide" option.

D.5. INFORMATION YOU MUST SUBMIT IF SELECTED FOR POSSIBLE AWARD

We may request additional necessary information from you during negotiations, or as required for award considerations. You must respond promptly.

If you do not fully comply with our information requests by the time we are ready to make an award, we may determine that you are not qualified to receive an award and use that determination as a basis for making an award to another applicant.

If your proposal includes human, animal, or rDNA research or involvement you must submit all documentation requested during negotiations or you may not receive an award.

Foreign recipients must complete a payment information form to receive wire transfer payments.

If selected for a contract award, a Section K Representations, certifications, and other statements of offerors or respondents will be provided for your completion, signature, and return. The document will include representations and certifications that your organization has not completed as part of the SAM registration, representations and certifications required by DoD Class Deviation(s), or that must be requested with each acquisition. The completed Section K will be incorporated into any resultant contract.

D.6. DUNS/UNIQUE ENTITY IDENTIFIER (UEI), CAGE, AND SYSTEM FOR AWARD MANAGEMENT (SAM)

D.6.a. SAM Registration Required

As required in 2 CFR 25.110 all applicants, unless exempted, must:

1) Be registered in SAM.gov before submitting its application;
2) Provide a valid **DUNS/UEI**; and
3) Continue to maintain an active SAM registration with current information at all times any Federal award is active, or any application is under consideration by a Federal awarding agency.

A Commercial and Government Entity (CAGE) code is obtained or specified as part of the SAM registration process. A CAGE code is required.

D.6.b. SAM Exemption or Exceptions Not Available Under This Announcement

We will not issue an Agency level exemption to SAM registration under 2 CFR 25.110(d)(1) for applicants under this announcement.

You must comply with SAM registration requirements and include a DUNS/UEI and CAGE code on your application or we cannot make an award.

Questions about SAM Registrations and Updates

You can get questions about SAM registration and entity updates answered by live chat at https://www.fsd.gov/fsd-gov/home.do and telephone at (866) 606-8220 or

(324) 206-7828. Top help topics for SAM.gov are available at

https://www.fsd.gov/fsd-gov/learning-center-system.do?sysparm_system=SAM.

D.6.c. Consequences of Non-Compliance with SAM Registration Requirements

We cannot make an award to you unless you comply with SAM requirements. If you are non-compliant, we may determine you are not qualified to receive an award, and use that determination to make an award to someone else as authorized by 2 CFR 25.205(b). You cannot receive payments without an active SAM record and CAGE.

D.7. SUBMISSION DATES AND TIMES

D.7.a. Proposal Submission

This announcement remains open until superseded. We review and evaluate proposals as they are received. You may submit proposals at any time; however, some specific topic instructions may recommend submission by specific dates that align with funding expectations. Funding is limited.

D.7.b. How Proposal Submission Time is Determined

We use the system-generated Grants.gov time stamp to determine when you submitted your successfully validated proposal and the announcement your submission was associated with. Grants.gov policies and procedures for application submission and processing apply. ***We will only accept applications submitted electronically through Grants.gov.***

D.7.c. Grants.gov Tracking Number is Application Receipt

Grant.gov generates a confirmation page when you submit your application. A second confirmation is provided by email when your application has passed Grants.gov validations and the status is updated from received to validated.

The confirmation page includes a system-generated Grants.gov tracking number; this serves as your receipt. You should keep a copy of all confirmations.

You can verify the submission time and application status with your tracking number through Grants.gov at http://www.grants.gov/web/grants/applicants/track-my-application.html.

D.7.d. Effect of Superseding Announcement

This announcement is open until superseded. We generally allow approximately thirty

(30) days for you to submit a proposal started under the announcement that is superseded before we close the previous announcement.

Grants.gov will not accept your proposal after we close a superseded announcement.

D.8. INTERGOVERNMENTAL REVIEW

N/A - This program is excluded from coverage under Executive Order (E.O.) 12372.

D.9. FUNDING RESTRICTION

D.9.a. Proposal Preparation Costs

Your proposal or application preparation costs are not considered an allowable direct charge to any award under this announcement. Your costs are, however, an allowable expense to the normal bid and proposal indirect cost as specified in 2 CFR 200.460 Proposal costs if you receive a grant or cooperative agreement, or FAR 31.205-18 Independent Research and Development and Bid and Proposal Costs for contracts.

D.9.b. Pre-Award Costs for Grants

You must request our approval prior if you need more than ninety (90) days pre-award cost authorization as described in 2 CFR 200.308(e)(1) and 2 CFR 200.458. **Your business office must provide this request in writing**. You must document why pre-award costs are necessary and essential for the research in the request, and identify a specific date for our Grants Officer to consider. We will only consider approval of a specific date of more than ninety days pre-award costs before an award is made.

Our grants include up to ninety (90) calendar days pre-award costs; however, the actual date costs become allowable is not final until an award is made. We recommend you ask for a specific date as described above to prevent misunderstandings.

All costs incurred before a grant or cooperative agreement award are at the recipient's risk as described in 2 CFR 200.308(e)(2). We are under no obligation to reimburse your costs if for any reason you do not receive an award, or if your award is less than anticipated and inadequate to your pre-award costs.

D.9.c. Pre-Contract Costs under FAR Cost-Reimbursement Contract Awards Not Available

Federal awards made using a 2 CFR 200.38(a)(2) cost-reimbursement contract instrument under the Federal Acquisition Regulations (FAR) do not allow for reimbursement of pre-contract costs. You will not get reimbursed for any costs you incur before the effective date of a contract award.

D.9.d. Air Force Office of Scientific Research No-Cost Extension (NCE) Guidance

We require prior written approval to extend the period of performance, without additional funds, beyond the expiration date of the grant. We only grant no-cost extensions when they are truly warranted and properly documented. For an extension to be granted, all NCE requests must be received from the Principle Investigator (PI) and at least 30 days prior to the expiration of the grant's period of performance. All PIs must submit NCE requests through the following website: https://community.apan.org/wg/afosr/p/nce_request. AFOSR will no longer accept NCE requests via email. All requests that are submitted through other avenues will have to be re-routed through the above website.

The NCE request must include:

a. Compelling reason(s) for the extension beyond the using unexpended balances.

b. Original end date and requested extension length.

c. SF 425 showing the unexpended funds remaining.

d. Request letter from Business office on University's letterhead

e. Ensure all required previous annual reports have been received by AFOSR

In no event will the period of performance be extended merely for the purpose of using unobligated balances.

D.9.e. Air Force Office of Scientific Research Additional Funding Request

Recipients are required to receive written approval for Additional Funding request to a grant, cooperative agreement, or contract to pay for essential items or activities that fall within the scope of that award, but were unanticipated at the time of award Supplemental funds can be requested for emergencies or other situations which result in unforeseen costs. For an additional funding request to be granted, you must provide notice in writing to the Program Officer using the appropriate email, at least sixty (60) days prior to the expiration of the award or prior to start of additional work to be performed. You must include a detailed budget justification for all additional work to be performed containing a breakout of the proposed cost. You should itemize labor, materials, supplies, travel, equipment (include quote), or any additional cost proposed.

Additionally, there may be an opportunity for short-term efforts called "Sprints", to be held at AFRL or other DoD facilities. If Sprints are proposed, there should be a Sprint Phase section to include specifics as to what would be accomplished during the "Sprint Phase" and specific travel duration/location explicitly stated in the proposal. "Sprints" are defined as an opportunity to showcase basic research impact performing grant relevant research and development activities within the context of DoD or sub-component experiments and initiatives at AFRL or other DoD facilities. Sprints will be evaluated the same as an additional funding action, whereas it must fall within the scope of the current awarded grant. In addition, the Sprint were unanticipated at the time that the new or competing extension request was submitted.

Be advised that the inclusion of the Sprint Phase in the proposal does not guarantee that the Government will award. Notification of incorporating the Sprint Phase will occur within 30 days to the start of the Sprint.

D.9.f. Prohibition on Contracting with Entities that Require Certain Internal Confidentiality Agreements or Statements—Representation

a. *Definition*. As used in this provision--

"Internal confidentiality agreement or statement", "subcontract", and "subcontractor", are defined in the clause at 52.203-19, Prohibition on Requiring Certain Internal Confidentiality Agreements or Statements.

b. In accordance with section 743 of Division E, Title VII, of the Consolidated and Further Continuing Appropriations Act, 2015 (Pub. L. 113-235) and its successor provisions in subsequent appropriations acts (and as extended in continuing resolutions), Government agencies are not permitted to use funds appropriated (or otherwise made available) for agreements with an entity that requires employees or subrecipients of such entity seeking to report waste, fraud, or abuse to sign internal confidentiality agreements or statements prohibiting or otherwise restricting such employees or subrecipients from lawfully reporting such waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

c. The prohibition in paragraph (b) of this provision does not contravene requirements applicable to Standard Form 312, (Classified Information Nondisclosure Agreement), Form 4414 (Sensitive Compartmented Information Nondisclosure Agreement), or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

d. Representation. By submission of its offer, the Grantor represents that it will not require its employees or subrecipients to sign or comply with internal confidentiality agreements or statements prohibiting or otherwise restricting such employees or subrecipients from lawfully reporting waste, fraud, or abuse related to the performance of a Government agreement to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information (e.g., agency Office of the Inspector General).

e. Agreement with the representation above will be affirmed by checking the "I agree" box in block 17 of the SF424 as part of the electronic proposal submitted via Grants.gov.

D.10. OTHER SUBMISSION REQUIREMENTS

If Grants.gov rejects your electronic application submission for any reason, you must correct all errors and resubmit your application.

E. APPLICATION REVIEW INFORMATION

E.1. CRITERIA

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

You should show strength in as many of the evaluation and selection areas as practicable to demonstrate maximum competitiveness.

E.1.a. Principal Evaluation and Selection Criteria

Our two (2) principal evaluation and selection criteria are specified in 32 CFR 22.315(c). Our principal selection criteria are of equal importance to each other. The combined principal selection criteria are more important than the additional evaluation and selection criteria.

Our principal evaluation and selection criteria are:

(1) The technical merits of the proposed research and development; and,

(2) Potential relationship of the proposed research and development to Department of Defense missions.

E.1.b. Additional Evaluation and Selection Criterion

Our sole additional evaluation and selection criterion for research proposals, which is of lesser importance than the primary evaluation and selection criteria combined is:

(1) The applicant's capabilities integral to achieving U.S. Air Force and Space 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 and Space Force objectives, and the potential risk of this effort to the U.S. Air Force and Space Force.

No further evaluation criteria or criterion will be used for proposal selection

E.2. REVIEW AND SELECTION PROCESS

E.2.a. Merit-based, Competitive Procedures

Proposals will be subjected to a peer or programmatic review. The peer review will use external reviewers to assess technical merit and Air Force and Space Force relevance of the proposal.

The programmatic review assesses the technical quality of the proposal, relevance of the proposed research to the portfolio descriptions in this BAA, relevance of the work to Air Force, Space Force and DoD needs, and the potential of the research balanced against the available funding resources of a given portfolio. Selection for award consideration will be made based on the outcome of these reviews

We select proposals for possible funding on a competitive basis according to Public Law 98-369, the Competition in Contracting Act of 1984, 10 USC 2361, and 10 USC 2374

using the merit-based, competitive procedures described in 32 CFR 22.315, incorporated here by reference.

E.2.b. Cost Analysis for Reasonableness and Realism

If your proposal is selected for possible award, we will analyze the cost of the work for realism and reasonableness. The cost of your proposal is considered, but is not an evaluation factor or criterion.

We must make sure the costs you propose are reasonable, realistic, and allocable to this work before we can make an award. All costs must be allowable to be reasonable. We may analyze your technical and cost information at the same time.

E.3. DISCLOSURE OF ADMINISTRATIVE PROCESSING BY CONTRACTOR PERSONNEL

We use support contractor personnel to help us with administrative proposal processing. Our contractor personnel are employees of commercial firms that have a contract with us. We make sure all of our support contracts include nondisclosure agreements that prohibit disclosure of any information you submit to other parties.

E.4. NO GUARANTEED AWARD

We do not guarantee that any award will be made under this competition.

F. FEDERAL AWARD ADMINISTRATION INFORMATION

F.1. SELECTION NOTICES

F.1.a. Electronic Notification

If your proposal is selected for possible award, an email will be sent to the principal investigator.

F.1.b. Selection for Possible Award Does Not Authorize Work

Our selection notice is not an authorization to start work, and is not an award guarantee. We will contact your business office to get answers to any questions we have about your proposal, and negotiate specific award terms.

F.2. AWARD NOTICIES

F.2.a. Federal Award Document

A grant or contract signed by a warranted Grants or Contracting Officer is the only official notice that an award has been made.

F.2.b. Electronic Federal Award Distribution

We send award documents to your business office by email. This is called award distribution. We always ask your business office to forward the award to the Principal Investigator indicated on the award document.

F.3. ADMINISTRATIVE AND NATIONAL POLICYREQUIREMENTS

F.3.a. Reporting of Matters Related to Recipient Integrity and Performance

You must report recipient integrity and performance information as required by Appendix XII to 2 CFR Part 200 – Award Term and Condition for Recipient Integrity and Performance Matters, incorporated here by reference. You should read the full text of this award term now using the link above to make sure you understand our requirements. You can also find this term at http://www.ecfr.gov.

F.3.b. Agency Review of Risk Posed by Applicants

(1) We must review information available about you and entities included in your proposal through the Office of Management and Budget (OMB) designated repositories of government-wide eligibility qualification and financial integrity information. Our risk review is required by 31 U.S.C. 3321 and 41 U.S.C. 2313, and includes both public and non-public information. You must be qualified and responsible as described at 32 CFR 22.415 Standards to receive a grant award. Contract applicants must be responsible based on the requirements in FAR Subpart 9.1 Responsible Prospective Contractors.

(2) We must consider the non-public segment of the Federal Awardee Performance and Integrity Information System (FAPIIS) for all awards exceeding the current simplified acquisition threshold of $150,000.

(3) At a minimum, the information in the system for a prior Federal award recipient must demonstrate a satisfactory record of executing programs or activities under Federal

grants, cooperative agreements, or procurement awards; and integrity and business ethics. We will consider any comments you provide, in addition to the other information in the designated integrity and performance system, when making our risk judgment about your integrity, business ethics, and record of performance under Federal awards.

(a) We may make an award to a recipient who does not fully meet our standards as described at 2 CFR 200.205(a)(2) if it is determined that the information is not relevant to the current Federal award under consideration or there are specific conditions that can appropriately mitigate the effects of the non- Federal entity's risk in accordance with 2 CFR 200.207 Specific conditions.

(4) We must comply with the guidelines on government-wide suspension and debarment described in 2 CFR 200.213, and must require you to comply with these provisions for all work we fund.

These provisions restrict Federal awards, sub-awards and contracts with certain parties that are debarred, suspended or otherwise excluded from or ineligible for participation in Federal programs or activities.

F.3.c. Cross-Cutting National Policy Requirements

You must comply with all applicable national policy requirements as a condition of award. Key national policy requirements may be found in the DoD Research and Development General Terms and Conditions (DoD T&C); and,

Appendix B to 32 CFR Part 22 – Suggested Award Provisions for National Policy Requirements that Often Apply, incorporated here by reference.

F.3.d. Acknowledgement of Research Support

You must acknowledge support provided by the Government in all materials based on or developed under our awards. The requirement extends to copyrighted and non-copyrighted materials published or displayed in any medium.

The following language must be used unless the award document provides different instructions:

"This material is based upon work supported by the Air Force Office of Scientific Research under award number FAXXXX-XX-X-XXXX."

You must require any sub recipients or subcontractors under your award to include this acknowledgement too.

F.3.e. Disclaimer Language for Research Materials and Publications

Some materials based on or developed under our awards must include special disclaimer language. You must include this language in all materials except scientific articles or papers published in scientific journals unless your award document provides different instructions:

"Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Defense."

You must require any sub recipients or subcontractors under your award to include this acknowledgement too.

F.3.f. Grants and Cooperative Agreements - Uniform Administrative Requirements, Cost Principles, and Audit Requirements

Our grants are governed by the guidance in Title 2, Code of Federal Regulations (CFR) Part 200, "Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards" as modified and supplemented by the Department of Defense's (DoD) interim implementation in 2 CFR Part 1103 [79 FR 76047, December 19, 2014] and 2 CFR Part 1125. Provisions of Chapter 1, Subchapter C of Title 32, CFR, "DoD Grant and Agreement Regulations" other than parts 32 and 33 continue to be in effect and apply as stated.

These regulations are incorporated by reference into this announcement.

F.3.g. Domestic Grants and Cooperative Agreements - DoD Research and Development General Terms and Conditions

Our domestic grants are subject to the "DoD Research and Development General Terms and Conditions" (DoD T&C) found at DoD Research and Development General Terms and Conditions.

These terms and conditions are incorporated by reference into this announcement. We can provide a generic model grant or cooperative agreement upon request.

We may award commercial grants to for-profit organizations

If we publish updated terms and conditions, the updated terms and conditions may apply to any grant made under this announcement.

F.3.h. Foreign Grants and Cooperative Agreements – Terms and Conditions

Our foreign grants and cooperative agreements are governed by award-specific terms and conditions that implement and supplement the section F.3.f. Uniform Administrative Requirements, Cost Principles, and Audit Requirements. We can provide a generic model grant or cooperative agreement upon request.

F.3.i. Contract Award Terms and Conditions

Our cost reimbursement contracts incorporate FAR, DFARS, and AFFARS clauses plus descriptive text tailored to the particulars of each procurement that combine as the terms and conditions of the contract. We can provide a generic model contract upon request.

F.3.j. Conditions of Award for Recipients Other Than Individuals

You must agree to comply with the requirements at 2 CFR Part 182, Subpart B "Requirements for Recipients Other Than Individuals" as a condition of award.

F.3.k. Contract Solicitation Provisions and Clauses Incorporated by Reference

The full text of FAR, DFARS, and AFFARS provisions and clauses may be accessed using the website at https://www.acquisition.gov/. The full text of Department of Defense (DoD) Class Deviations from the FAR and DFARS may be accessed at http://www.acq.osd.mil/dpap/dars/class_deviations.html. Any contract award will include all clauses required by FAR, DFARS, and AFFARS at the time of award.

We always include the full text of DFARS 252.227-7017 Identification and Assertion of Use, Release, or Disclosure Restrictions in your Section K. We have to understand any

data restrictions before negotiations. You should read the full text of this provision now at https://www.acquisition.gov/dfars/part-252-solicitation-provisions-and-contract-clauses#DFARS-252.227-7017.

52.203-18 Prohibition on Contracting with Entities that Require Certain Internal Confidentiality Agreements or Statements - Representation (Jan 2017)

52.209-11 Representation by Corporations Regarding Delinquent Tax Liability or a Felony Conviction under any Federal Law (Feb 2016)

252.204-7007 Alternate A, Annual Representations and Certifications (Nov 2020)

252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting (Dec 2019)

252.209-7004 Subcontracting with Firms that are Owned or Controlled by the Government of a Country that is a State Sponsor of Terrorism (May 2019)

252.227-7013 Rights in Technical Data--Noncommercial Items (Feb 2014)

252.227-7017 Identification and Assertion of Use, Release, or Disclosure Restrictions (Jan 2011)

252.235-7010 Acknowledgement of Support and Disclaimer (May 1995)

252.235-7011 Final Scientific or Technical Report (Dec 2019)

252.244-7001 Contractor Purchasing System Administration-Basic (May 2014)

252.239-7010 Cloud Computing Services.

F.3.l. Foreign Entities and For-Profit Organizations Not Generally Eligible for Equipment Vesting

We cannot vest title to equipment with for-profit organizations, foreign public entities, or foreign organizations unless there is a specific statutory or regulatory authority that allows us to do so.

- If you are applying for a contract award, you should contact us before you propose purchasing equipment.
- If you are applying as a foreign public entity or foreign organization, please contact the Program Officer listed with your topic before you propose equipment.

F.3.m. Minimum Record Retention Requirements

You must keep records related to our awards for at least three years after completion and the final Federal Financial Report is submitted. This requirement is described further in 2 CFR 200.334, incorporated here by reference. For grant or cooperative agreement awards, the DoD T&C OAR Article II. Records retention and access describes additional requirements. Contract awards have similar requirements.

Sometimes records must be retained for more than three years.

F.4. REPORTING

F.4.a. Monitoring and Reporting Program Performance

All of our awards require at least annual and final technical performance reports as required in 2 CFR 200.328. The DoD T&C REP Article I. Performance reporting will apply to grant or cooperative agreement awards. Some of our awards require more frequent technical reports.

You must provide your reports on time. Our awards include a schedule specifying the latest date for submission of each required report. Failure to provide required reports, or providing reports after required due dates, could lead to being considered ineligible for future awards.

You may use a SF 298 Report Documentation Page for interim progress reports.

You must use a completed SF 298 Report Documentation Page as the first page of the final report. You can download an electronic SF 298 from http://www.gsa.gov/portal/forms/download/116146.

F.4.b. Technical Performance Report Format

(1) Federal-wide Research Progress Performance Report (RPPR) Format (All grant awards)

We now use the Federal-wide Research Progress Performance Report (RPPR) for annual and final research performance reports. The reporting requirements will be detailed in the grant award documents.

(2) ANSI Standard Z39.18-2005 (all non-grant awards)

Use the AFRL Scientific & Technical Reports – Preparation, Presentation and Preservations Format Guidelines (June 2010) for your final report unless your award states different requirements. You can download the AFRL standard guide from the Related Documents tab in Grants.gov for this announcement.

F.4.c. Department of Defense (DD) Form 882 Report of Inventions and Subcontracts

(1) Invention Reports

(a) You must provide at least a final invention report on DD Form 882. We may ask for annual reports. Our award documents specify the due date. You can get the form at http://www.dtic.mil/whs/directives/forms/eforms/dd0882.pdf.

(b) You must submit invention reports even if you do not have a patent to report.

(2) Sub-Award and Subcontract Reporting

You must use the DD Form 882 to tell us about any subawards or subcontracts. Your award will provide specific instructions. You can get the form at http://www.dtic.mil/whs/directives/forms/eforms/dd0882.pdf.

F.4.d. Standard Form (SF) 425 Federal Financial Report

Our awards require a final SF 425 Federal Financial Report. You can get the form at

http://www.whitehouse.gov/sites/default/files/omb/assets/grants_forms/SF-425.pdf.

(1) If you request any advance payment(s) under your award or have scheduled payments, you must submit quarterly SF 425 reports for the life of the award. Our awards include specific instructions.

(2) You do not have to submit quarterly SF 425 reports if you only request payments by reimbursement.

F.4.e. Electronic Payment Requests and Electronic Payment

You must submit payment requests electronically using the Invoicing, Receipt, Acceptance, and Property Transfer (iRAPT) application unless your award specifies different instructions. Domestic grant payments must be made using the electronic funds transfer (EFT). We prefer to make foreign payments by wire transfer.

To submit electronic payment requests you must register to use iRAPT in the Wide Area Workflow (WAWF) e-Business Suite at https://wawf.eb.mil. The website includes registration instructions.

If you have WAWF or iRAPT questions or problems, you can get help by telephone at (866) 618-5988 or (801) 605-7095, by electronic mail at disa.ogden.esd.mbx.cscassig@mail.mil, or the website https://wawf.eb.mil/xhtml/unauth/web/homepage/vendorCustomerSupport.xhtml.

F.4.f. Property Reports

If we furnish any property owned by the Government under an award, you must submit periodic property status reports as described in 2 CFR 200.329 and further implemented for grants by the DoD T&C REP Article III. Reporting on Property. Contract awards have similar property reporting requirements.

F.4.g. Other Reports

Our Program Officers may ask for informal technical reports as needed. We use these informal reports for program purposes, such as preparation for meetings and other technical purposes. We highly recommend you provide this information in a timely manner by electronic mail directly to the Program Officer.

F.4.h. Electronic Submission of Reports

You must plan on submitting reports electronically. **You must submit most reports through the internet application detailed in the grant award document**. Some reports must be sent using electronic mail. Our award documents provide specific instructions that you must follow.

G. AGENCY CONTACTS

G.1.a. TECHNICAL INQUIRESAND QUESTIONS

You should submit your questions in writing by electronic mail to the Program Officer responsible for your topic(s) of interest from section A. Program Description. You should include the announcement number in the subject line.

The technical contacts for this announcement by program description are as follows:

SECTION	PROGRAM DESCRIPTION	PROGRAM OFFICER
A.1.a.	Dynamic Materials and Interactions	Dr. Martin Schmidt
A.1.b.	GHz-THz Electronics	Dr. Kenneth C. Goretta
A.1.c.	Energy, Combustion, and Non-Equilibrium Thermodynamics	Dr. Chiping Li
A.1.d.	Unsteady Aerodynamics and Turbulent Flows	Dr. Gregg L. Abate
A.1.e.	High-Speed Aerodynamics	Dr. Sarah Popkin
A.1.f.	Aerospace Composite Materials	Dr. Ming-Jen Pan
A.1.g.	Multiscale Structural Mechanics and Prognosis	(acting) Dr. Martin Schmidt
A.1.h.	Propulsion and Power	Dr. Mitat A. Birkan
A.1.i.	Agile Science for Test and Evaluation (T&E)	Dr. Brett Pokines
A.2.a.	Computational Cognition and Machine Intelligence	(acting) Dr. Hal Greenwald
A.2.b.	Computational Mathematics	Dr. Fariba Fahroo
A.2.c.	Dynamical Systems and Control Theory	Dr. Frederick Leve
A.2.d.	Dynamic Data and Information Processing	Dr. Erik Blasch
A.2.e.	Information Assurance and Cybersecurity	Dr. Tristan N. Nguyen
A.2.f.	Mathematical Optimization	Dr. Warren Adams
A.2.g.	Science of Information, Computation, Learning, and Fusion	Dr. Richard D. (Doug) Riecken
A.2.h.	Trust and Influence	Dr. Laura Steckman
A.2.i.	Complex Networks	Dr. Donald K. Wagner
A.2.j.	Cognitive and Computational Neuroscience	Dr. Hal Greenwald
A.3.a.	Aerospace Materials for Extreme Environments	Dr. Ali Sayir
A.3.b.	Atomic and Molecular Physics	Dr. Boyan Tabakov
A.3.c.	Electromagnetics	Dr. Arje Nachman
A.3.d.	Laser and Optical Physics	Dr. Briana Singleton
A.3.e.	Optoelectronics and Photonics	Dr. Gernot S. Pomrenke
A.3.f.	Plasma and Electro-Energetic Physics	Dr. John Luginsland
A.3.g.	Quantum Information Sciences	Dr. Grace D. Metcalfe
A.3.h.	Physics of Sensing	Dr. Michael Yakes
A.3.i.	Space Science	Dr. Julie J. Moses
A.3.j.	Ultrashort Pulse Laser-Matter Interactions	Dr. Andrew Stickrath
A.3.k.	Condensed Matter Physics	Dr. Jiwei Lu
A.4.a.	Biophysics	Dr. Sofi Bin-Salamon
A.4.b.	Human Performance and Biosystems	Dr. Patrick O. Bradshaw
A.4.c.	Mechanics of Multifunctional Materials and Microsystems	Dr. Byung-Lip (Les) Lee
A.4.d.	Molecular Dynamics and Theoretical Chemistry	Dr. Michael R. Berman

A.4.e.	Natural Materials and Systems	(acting) Dr. Patrick Bradshaw
A.4.f.	Organic Materials Chemistry	Dr. Kenneth Caster
A.6.	Other Innovative Research Concepts	Dr. Van Blackwood

If you submit a question by telephone call, fax message, or other means you may not receive a response.

G.1.b. GENERAL INQUIRIES AND QUESTIONS

You must send all general questions about this announcement to us by email. Your questions will generally be consolidated with other questions and posted on Grants.gov so everyone gets the same information. We may provide an individual response by email if your question does not apply to anyone else.

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Procurement Analyst
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H. OTHER INFORMATION

H.1. 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, grants 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 grant or 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 grants or 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 GO, concerned parties may contact the AFRL Ombudsman, Director of Contracting, HQ AFRL/PK. The AFRL Alternate Ombudsman is the Deputy Director of Contracting, HQ AFRL/PK. Please send an email to afrl.pk.workflow@us.af.mil with the subject of "Ombudsman".

(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 grants or contracting officer.

H.2. GRANTS AND CONTRACTING OFFICERS AUTHORITY

Grants and Contracting Officers acting within their warranted capacity are the only individuals legally authorized to make commitments or bind the Government.

No other individuals are authorized to make commitments or otherwise bind us.

H.3. FUNDINGOPPORTUNITIES

We post new funding opportunities throughout the year looking for today's breakthrough science for tomorrow's Air Force and Space Force. You can find more information about Air Force Office of Scientific Research interests and funding opportunities on our website at http://www.wpafb.af.mil/afrl/afosr.