AFRL

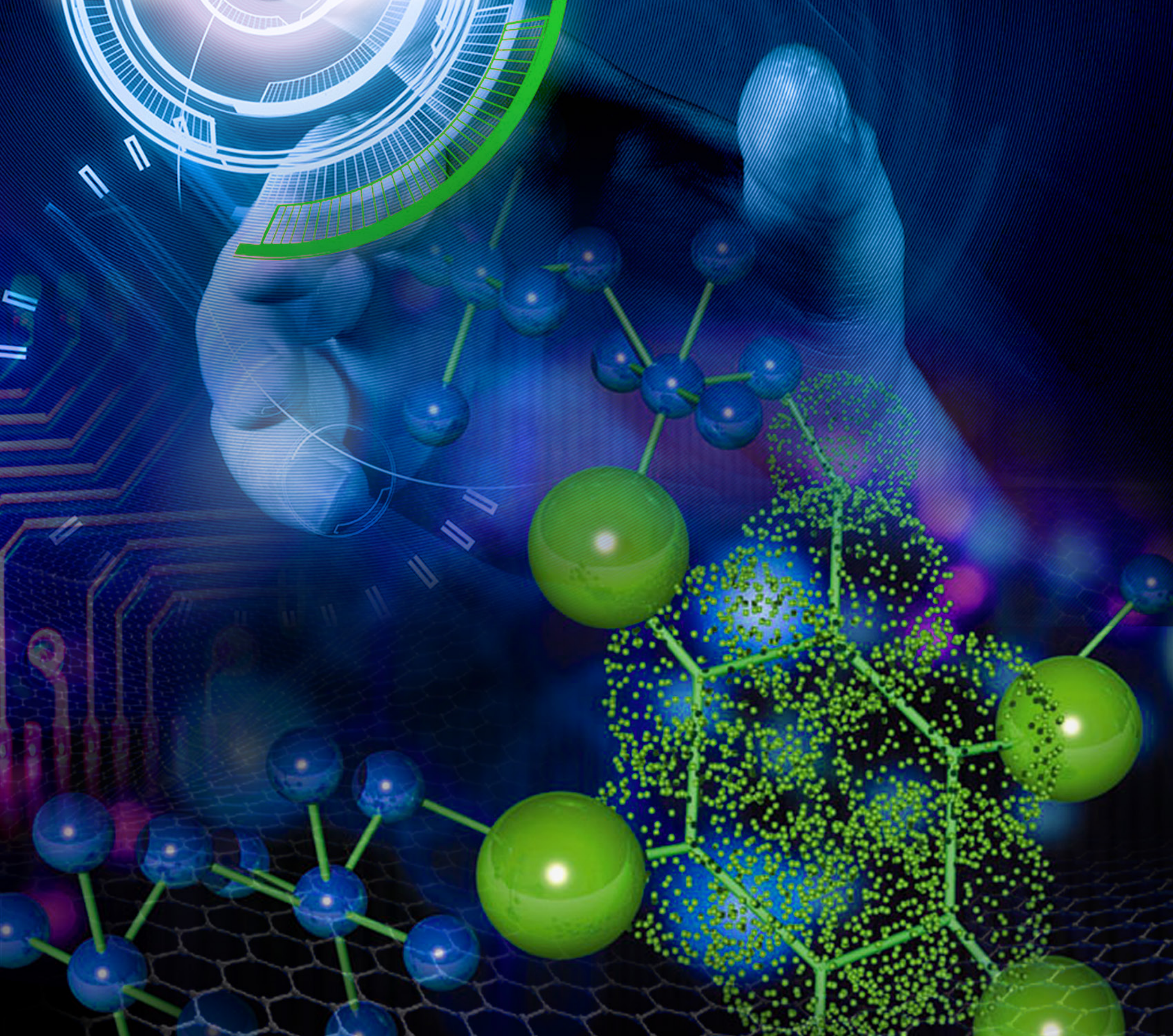
THE AIR FORCE RESEARCH LABORATORY

LEAD | DISCOVER | DEVELOP | DELIVER

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

2014 TECHNICAL STRATEGIC PLAN

AFOSR



Message from the Director

DISCOVER

SHAPE

CHAMPION

Our vision is bold: The U.S. Air Force dominates air, space, and cyberspace through revolutionary basic research.

Our mission is challenging: We discover, shape, and champion basic science that profoundly impacts the future Air Force.

Three enduring core strategic goals ensure that AFOSR stays committed to the long-term technological superiority of the Air Force.

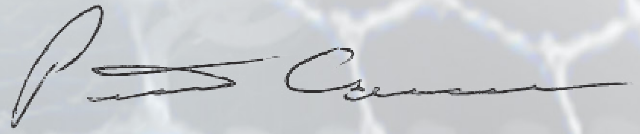
- We identify opportunities for significant scientific advancements and breakthrough research around the world.
- We rapidly bring to bear on these opportunities the right researchers and resources in the interest of fostering revolutionary basic research for Air Force needs.
- We enable the Air Force to exploit these opportunities through transitioning revolutionary science and technology to DOD and industry.

Dr. Patrick Carrick
Acting Director, Air Force Office of Scientific Research

I am pleased to present the Air Force Office of Scientific Research (AFOSR) Technical Strategic Plan. AFOSR is the basic research component of the Air Force Research Laboratory. For over 60 years, AFOSR has directed the Air Force's investments in basic research. AFOSR was an early investor in the scientific research that directly enabled capabilities critical to the technology superiority of today's U.S. Air Force, such as stealth, GPS, and laser-guided weapons. This plan describes our strategy for ensuring that we continue to impact the Air Force of the future.

Our basic research investment attracts highly creative scientists and engineers to work on Air Force challenges. AFOSR builds productive, enduring relationships with scientists and engineers who look beyond the limits of today's technology to enable revolutionary Air Force capabilities. Over its history, AFOSR has supported more than 70 researchers who went on to become Nobel Laureates. Furthermore, AFOSR's basic research investment educates new scientists and engineers in fields critical to the Air Force. These scientists and engineers contribute not only to our Nation's continued security, but also to its economic vitality and technological preeminence.

I am honored to be the Director of the AFOSR. The challenges that the Air Force confronts will forever be changing. AFOSR will respond to meet those challenges.

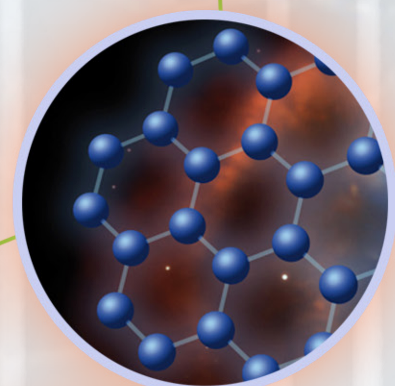


Introduction

Today's U.S. Air Force dominance is the direct result of more than 60 years of investment in the sciences and technologies that underlie air and space power and information production and use. This broadly based investment ranges from focused research, enabling rapid development of specific systems and capabilities, to the most basic research in existing and emerging sciences. Continuing commitment to comprehensive investment provides the Air Force with a technological edge that manifests itself in our current preeminent air, space, and information systems.

The Air Force Office of Scientific Research (AFOSR) directs the investment of Air Force's basic research funds into subjects that reveal, define, and explore emerging scientific concepts and assesses their applicability to tomorrow's Air Force. AFOSR is the directorate within the Air Force Research Laboratory (AFRL) that focuses exclusively on the future. Across the Air Force there is a shared vision of reliance on and demand for technological superiority. AFOSR's vision and mission have the unique feature of focusing on revolutionary, transformational basic research, producing today's breakthrough science for tomorrow's Air Force.

Fulfilling our three core strategic goals ensures the AFOSR remains a constant and capable custodian of the long-term technological future for the Air Force, the Department of Defense (DOD), and the country. This document addresses how AFOSR identifies which activities to fund, the thought processes that underlie allocation of resources, and what steps are taken, in which directions, to support transitioning research results. Details of the processes that drive transitions are discussed further in AFOSR's Strategic Business Plan.



Elements of Strategy

AFOSR is a mission agency. Its goals – to discover, shape, and champion basic science that profoundly impacts the future Air Force – are unique within the Air Force and among governmental funding agencies. They are inextricably tied to the mission and strategic priorities of the entire Air Force and are necessarily based on the plans and programs of AFRL.

AFRL leads the discovery, development, and integration of affordable technologies that assure at all times and in all engagements the dominance of our aerospace forces. AFRL must consider broad spectrums of time, place, and operation, ranging from rapid response to meet today's warfighter needs to far-term transformational research and development that prepares the air Force for the challenges that will emerge in the future. As the AFRL directorate responsible for directing all basic research investments, AFOSR must be keenly attuned to transformational research across the globe and its relations to the needs and plans of the current and future Air Force.

The processes AFOSR follows in making its investment decisions, intent on maximizing their impacts, are based on the three strategic goals. AFOSR must seek out and support the best, most transformational basic research with the greatest potential for impact on the future Air Force. This objective requires, first and foremost, that AFOSR's Program Officers be assigned appropriate responsibilities and that they be provided with the support necessary for them to take steps that will, over time and over a broad set of portfolios, create the Air Force of the future. The main considerations that assemble and unleash an effective technical workforce and underlie its investment decisions are described below.

Identify opportunities for significant scientific advancements and breakthrough research around the world

This first strategic goal is the foundational element for AFOSR. If as an organization it identifies opportunities well, the other two strategic goals can be addressed well. Identification of where a research revolution may develop is the most difficult of the three goals. It is inherently the most risky and it commands the most resources and energy.

Input into decisions

Program Officers and leadership determine how and where to look for breakthrough research opportunities. They consider the current and projected technological needs of the Air Force and the full scope of research reported on, in progress, and planned throughout the world. AFOSR acquires the knowledge it needs on the technological status and gaps of the Air Force by direct personal contacts and by studying relevant publications and declarations from the DOD and the Air Force (primarily the Chief Scientist, the major commands, and AFRL). To assure the information is current, accurate, and complete, AFOSR maintains relationships with its stakeholders, exchanging information and ideas regularly. The knowledge accumulated informs decisions on the broad subjects of research on which to focus and whom to hire as Program Officers.

An example of the input that informs AFOSR decisions is shown in Table 1, which was compiled from "Air Force Research Laboratory Capability-Based Science and Technology Strategy 2030" and "Global Horizons: United States Air Force Global Science and Technology Vision." These documents and many others reflect substantial agreement as to the various trends that are driving change worldwide and that will impact the Air Force and the U.S. military in the coming years. Other published guidance on science and technology that is relevant to AFOSR is shown in the Reference section.

Table 1. Major Global Trends Expected to Impact the Air Force

Asia Rising

Projected to reach a combined population of 2.7 billion people by 2020, China and India have among the world's highest growth rates in economic and military strength. This trend could portend the re-emergence of a peer competitor.

Urbanization Accelerating

The ongoing largest migration in history places populations and power centers in complex, confined environments that "can degrade or reduce the effectiveness of high-technology weapons; communication systems; and intelligence, surveillance, and reconnaissance (ISR) capabilities."

Globalization and Interdependence Increasing

"Economic, financial, industrial, and information globalization represent the leading edge of market forces driving us toward a more interdependent global framework of political and ideological engagement." Alliances and partnerships will evolve, and probably in aggregate expand over time.

Resource Competition Emerging

Availability of energy and vital resources for the world as a whole must be considered in forming military technology strategy.

Economic Environment Evolving

Inconsistent, but overall strong growth throughout developing world and slowing of growth in the U.S. and the developed world, coupled with rising costs of military personnel and systems, elevate economic considerations to paramount position for development of new technologies.

Asymmetric Engagement Persisting

The number of failed and failing states may expand. Those marginalized and disenfranchised as a result of history, geography, globalization, and urbanization will not confront those they perceive as oppressors directly.

U.S. Technological Edge Declining

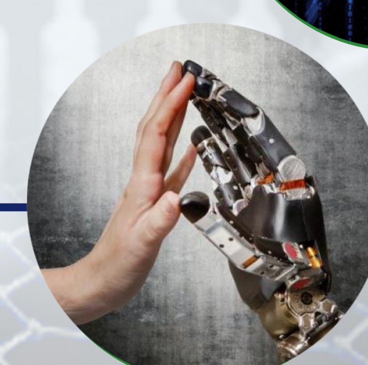
The rest of the world is developing. Because of growing populations, improvements in education, expanding economies, and ambitions of (comparative) power throughout the world, "it is unlikely our nation will continue to have the science and engineering edge it once enjoyed."

Military Use of Space Expanding

The unrestricted use of space as a domain that enables us to see, hear, locate, and communicate on a global scale is essential to operations. Proliferation of assets and debris and rise of directed-energy weapons imperil our capabilities.

Cyberspace Ubiquitous to Operations, while Cyber Threats Exploding

Information technology, advanced and ubiquitous communications, and unfettered use of the electromagnetic spectrum have been great strengths in terms of enhancing the security, connectivity, and sensory abilities of our nation—but embedded in our reliance is also a great weakness, should it be denied.



New Technologies Emerging

History has shown that we usually underestimate significantly the impact of emerging technologies. This is particularly true of technologies that are so new that their influence cannot be reliably predicted.

Elements of Strategy

AFOSR makes investments in research with potential for application beyond today's prevailing assessments of Air Force needs in order to capture truly transformational scientific breakthroughs that have the potential to profoundly change the Air Force. Transformational advances often occur where they are not expected, and so AFOSR focuses on early recognition of unexpected advances in science and technology, emerging scientific breakthroughs, and disruptive technologies.

Decision makers

This search for transformational opportunities is carried out primarily by AFOSR's Program Officers. They are required to be intimately familiar with advances in their technical subjects and to be active participants in their research communities. They are selected on the basis of their technical capabilities and because they have evinced entrepreneurial approaches to their jobs, have built programs, and have pioneered advances in research. The organization must be structured and processes must be designed to support the search for transformational research and to allow the Program Officers to succeed in nurturing it once found.

Management of technical portfolios, from conception through evolution to transition, is a creative enterprise. It must be supported adequately in each phase to allow multiple inputs to be synthesized into uniquely crafted research portfolios that will shape the progress of diverse fields. Baseline requirements for AFOSR's programmatic staff include digital access to a high-quality technical library (including data-mining capabilities), assignment of duties to appropriate parties (administrative burdens are best born by administrative staff), and means to engage substantively the relevant research communities. Mechanisms of engagement necessarily include direct personal contact at conferences, workshops, program reviews, and site visits. Personal contact is supplemented by various electronic means of communication, but the latter cannot replace the former. Only In-person communication can establish the relationships needed to identify and evaluate the most-compelling opportunities for investment and can assure knowledge is current and extensive. Because AFOSR's investments significantly influence the development of new fields of study, rapid identification of opportunities is essential.

Truly transformational research can come from anywhere. AFOSR must look broadly across all perceived future Air Force technological needs through the lens of transformational change and across the entire world of science and technology. To maintain vigilance of the evolution of science across the globe and to exploit any scientific advances, if and when appropriate, AFOSR maintains three overseas offices: the Asian Office of Aerospace Research and Development (AOARD) in Tokyo, the European Office of Aerospace Research and Development (EOARD) in London, and the Southern Office of Aerospace Research and Development (SOARD), in Santiago, Chile. These offices support direct interchanges with the world's scientific and engineering community, through participation in a wide range of meetings and development of a large number of working relationships.

Rapidly bring to bear the right researchers and resources on these opportunities in the interest of fostering revolutionary basic research for Air Force needs

Identification of promising opportunities for investments in research must be comprehensive and informed by an understanding of the strategic directions of the Air Force, AFRL, and the DOD as a whole. Within the two overarching guidelines—opportunity in research and applicability to the Air Force—AFOSR must balance its investment across subjects of research based on its best understanding of future trends in science and technology and of the projected needs of warfighters. It must balance its investments among research enterprises: domestic universities and laboratories, AFRL's laboratories, small businesses, and foreign universities and laboratories. It must consider the extent to which other agencies, inside and outside DOD, are investing in similar activities and assure that its investments are appropriately coordinated with those agencies. It must also consider the Air Force's need to develop and support its own staff of excellent researchers and world-class research facilities.

AFOSR inherently addresses difficult technical problems. Some advances, especially in rapidly changing fields such as information science, may require only months to achieve success and move to transition. Others may require decades of consistent support. The questions to answer on researchers, resources, and results are these: (1) What research to support? (2) Where to support it and why? (3) How much funding is needed and is leverage possible? (4) How long to fund the research? (5) How can success be determined? (6) If successful, what is required to ensure transition to the Air Force, DOD, or industry?

What:

The main consideration for deciding what to fund was discussed in the context of Strategic Goal 1: the need to support transformational research that could lead to a breakthrough, in a field that is expected to be relevant to the Air Force at some future time. AFOSR management works with other AFRL personnel and

WHAT

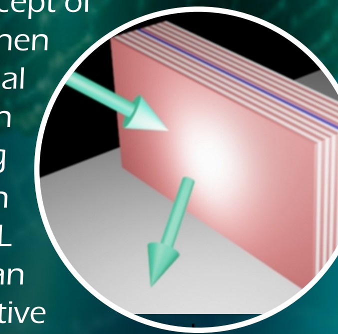
WHERE

HOW MUCH

HOW LONG

HOW SUCCESSFUL

Reflective Optical Limiter



The Air Force has been seeking a way to protect pilot's eyes and aircraft sensors from being damaged by intense laser pulses. Initially, the concept of gradually darkening sunglasses that protect the wearer's eyes when they step into bright sunlight, but quickly return to their normal state when indoors, was pursued, but no version could darken quickly enough to ameliorate short laser pulses. With funding from AFOSR, collaborative research undertaken by physicists from the AFRL Sensors Directorate and Wesleyan University, conceptualized the Reflective Optical Limiter to address this threat via a periodic layered structure with an embedded nonlinear layer within the lens. Such a layered structure acts as a self-protecting power limiter. At low intensity of the incident light, the entire stack is highly transmissive, but when the input power exceeds a certain level, the stack becomes highly reflective over a broad frequency range, regardless of the angle of incidence. The excessive radiation is reflected back to space, rather than being asorbed by the limiter. This prevents overheating and destruction of the limiter.

its stakeholders and follows published guidance to determine, to the extent it can, what is most likely to be relevant. Major emphasis is placed on research where AFOSR can have a significant impact, where support from other sources is missing or inadequate.

Where:

Decisions on how in aggregate to distribute funding among research at domestic universities and laboratories, in-house research at AFRL, and foreign universities and laboratories are influenced by many factors. Because the U.S.-based university research establishment is by far the strongest in the world and because, like all Federal science funding agencies, AFOSR is committed to maintaining our national strength and to producing the nation's next generation of scientists and engineers, well over 90% of funds are spent within the United States. AFOSR invests in foreign research when it is unique and it complements that found domestically. It strives to develop strong relationships with its cadre of foreign researchers to promote exchanges of information and ideas and to seed transnational partnering.

How much:

The economic constraints on AFOSR are severe. AFOSR maximizes the impact of its funding by disciplined buying and by leveraging its investments whenever possible. The first set of questions to be asked in this context addresses how much money is needed to provide reasonable assurances that significant advances can be made. The second set addresses what research other agencies are funding. Many other governmental agencies, inside and outside DOD, fund basic research that could potentially impact the future Air Force. The responsibility for understanding and dealing with the overlap of AFOSR's interests with those of other agencies resides at both the Program Officer and management levels. They coordinate with their counterparts in other funding agencies and balance their investments accordingly. There are fields of research of obvious or likely importance to the Air Force in which AFOSR invests modestly because other agencies take the lead. There are also fields of research in which funds among agencies are combined by agreement, so that each agency reaps maximum benefits. The Assistant Secretary of Defense for Research and Engineering coordinates basic research investment across the services when there is considerable overlap of interests.

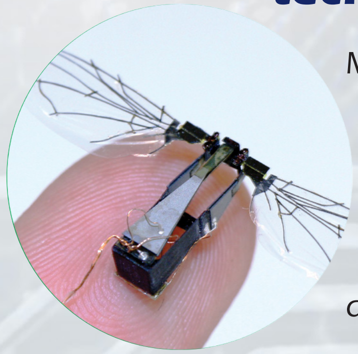
How long:

Individual projects typically run for three to five years. Many projects are, of course, renewed. There is a continuous balancing act between support of new activities and continued funding of existing work, taking into account progress of current work, transition of current work into an applied research or application phase, and worldwide opportunities in emerging science. Internal reviews and allocation of resources by AFOSR's Director assure introduction of new subjects and portfolios.

How successful:

Research portfolios are assessed throughout the year. AFOSR holds an annual review of its entire research portfolio. Scientific Advisory Board (SAB) reviews are convened every two years to assess the distribution of investments and the progress made and promise offered by each portfolio under examination. The recommendations made by the SABs have significant influence on evolutions of and distributions within portfolios. In addition, each Program Officer holds a yearly program review, which assures exchange of current, vital information among the assembled researchers and allows the Program Officers to determine the courses of their investments, to make informed decisions on future funding, to change course (when appropriate), and to forge alliances and build teams of research groups. Over the long term, the primary metric for success is the evidence of transformational impact on the Air Force. In the near term, obvious measures of research output apply, although they can never supply definitive answers to questions of investment success. AFOSR tracks major awards garnered by its principal investigators, along with publications, presentations, and patents; graduation rates in U.S. universities; and in-house capabilities and productivity within AFRL. It focuses considerable attention on the research communities it affects. One measure of success is the arc of a community, roughly its ascent or decline. To the extents possible, AFOSR seeks to build and grow vibrant research communities and, in some cases and over periods that may vary widely, eventually to wean the communities from AFOSR's funding.

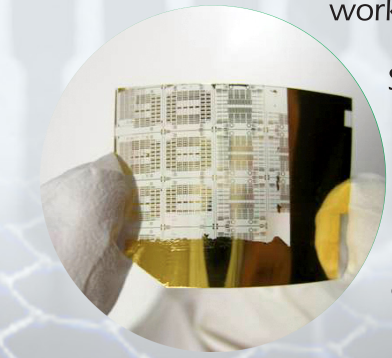
Enable the Air Force to exploit these opportunities at the appropriate time through transitioning revolutionary science to DOD, technology incubators, and industry



Most successes in research are proclaimed proudly and disseminated widely, and yet transitions of results to various stages of technological development do not always occur. The success rate of transitions is determined by the results in question, the extents to which they are understood and are clearly articulated, the receptivity and resources of potential transition partners, and the quality of communications between the various parties. AFOSR's Program Officers and managers influence each of these factors, and they serve as agents to link researchers with partners for development.

As a strategic necessity, AFOSR must ensure results from the research it funds are disseminated within appropriate communities of science and technology, are expressed clearly (re-expressed, if necessary, so as to be understandable by a broad swath of the community), and, when warranted, are provided directly to possible transition partners. The same skill set and knowledge base that support AFOSR's Program Officers and managers in pursuit of Strategic Goal 1 (identify in what to invest) provide ability to understand and assess transition possibilities for research results. The same entrepreneurial spirit motivates and mobilizes efforts to transition results.

Trusted personal relationships are often required to move from research by one party to technology development by another. The most common transition partners for AFOSR are the other Technology Directorates in AFRL. Close relationships are maintained on all aspects of AFOSR's activities and the other Technology Directorates' needs and goals. Transitioning from basic research to applied research or technology development is simply one more reason the Technology Directorates work together closely.



Some research breakthroughs may best be transitioned to entities other than those within AFRL. Many examples exist of moving from basic research directly to industry or the Air Force user community. It is vital AFOSR maintain relationships with these key stakeholders. As noted above, they also help inform AFOSR's search for breakthroughs in research and its investment decisions. Having them participate broadly in AFOSR's activities and maintaining substantive dialogue greatly increase the chances of successful transition.

Organizational Structure and Technical Focus

Organizational Structure

AFOSR functions within a worldwide research community that is changing rapidly and profoundly. It is committed to responding quickly and forcefully to consequential change and to applying wisely the resources necessary to advance science and technology for the Air Force. Its Program Officers work together for synergy across technical areas and with colleagues in AFRL and the broader community so that its investments at the basic research level can help support other investments in basic and applied subjects. AFOSR's location near the nation's capital promotes efficient information exchange, collaboration, and sharing of resources with counterparts in other governmental agencies.

AFOSR has long been among the most adaptable of federal funding agencies. To become even more so and to engage more effectively the research organizations it supports and influences, it revamped its structure in early FY13. AFOSR's program management enterprise is now organized into divisions, each of which is led by a Chief who reports to a Director. The Directors and Chiefs are responsible for integrating and executing the organization's technical strategy. There are currently five AFOSR research divisions, which are called Departments, and four international divisions. Reporting to the Director of the Basic Science Program Office (RT) are:

Dynamical Systems and Control (RTA)
Quantum and Non-equilibrium Processes (RTB)
Information, Decision, and Complex Networks (RTC)
Complex Materials and Devices (RTD)
Energy, Power, and Propulsion (RTE)

Their current portfolios and plans are discussed below. Reporting to the Director of the International Science Program Office (IO), who is parallel with RT, are:

Asian Office of Aerospace Research and Development (IOA)
European Office of Aerospace Research and Development (IOE)
International Office Arlington (ION)
Southern Office of Aerospace Research and Development (IOS)

Restructuring of AFOSR, primarily going from three to five divisions and integrating the international offices, was based on improving coordination with academia and the broader research community and promoting collaboration. The research Departments are a flexible construct that can evolve rapidly in response to significant shifts in the scientific environment. Departments can close or consolidate, as needed, and new Departments can be created with comparative ease. Their Chiefs serve for two years. Frequent exchange of managers grows executive talent and promotes introduction of vibrant new ideas and approaches. That all Chiefs report to a single Director who is focused fulltime on the scientific part of AFOSR ensures proper coordination and balance of portfolios and resources among the Departments.

The international divisions work within environments quite different from the domestic counterparts. They, too, are changing rapidly, but the dimension of time impacts AFOSR's international programs as much on a personal level as a technological one. Creation and cultivation of strong international programs and collaborative research portfolios require considerable accumulated experience and development of trusted relationships with researchers and research leaders. The number of overseas offices has been fixed for years and will remain so for the foreseeable future. The Chiefs of these divisions are expected to be in place for at least three years to support continuity and consistent access to all levels of leading foreign and domestic research institutions.

Reorganization of the enterprise did not change the number or natures of the international offices. It did meld them into a single entity with a single Director. Better integration of programs was sought and achieved. The previous geographical boundaries that separated AOARD, EOARD, SOARD, and the International Office in Arlington inhibited collaboration at times and induced inefficiencies in several business practices. The fully integrated Inter-national Science Program Office considers the world as a whole and makes its investments without the artificial need to balance them among offices.

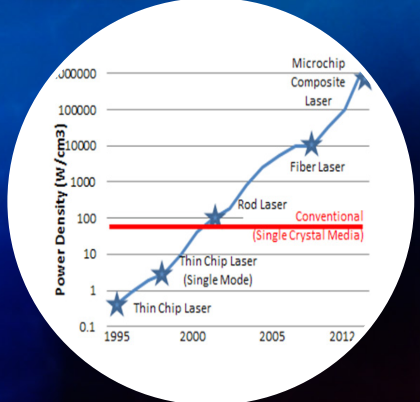
RT AFOSR Technical Directorates
RTA Dynamical Systems and Control
RTB Quantum and Non-equilibrium Processes
RTC Information, Decision, and Complex Networks
RTD Complex Materials and Devices
RTE Dynamical Systems and Control

IO International Science Program Office
IOA Asian Office
IOE European Office
ION Arlington VA
IOS Southern Office

Technical Focus

AFOSR often helps new fields of research emerge and cohere. Our investments often feed into drafting of guidance from the Air Force and DOD. We also receive guidance and adapt to it. Some of the major external input that went into departmental structure and the Program Officer portfolios can be summarized briefly. Since AFOSR's Technical Strategic Plan was last written, the following primary guidance was addressed by AFOSR.

High-Energy Solid-State Lasers



High-energy solid-state lasers require gain materials that are not currently available through single-crystal growth methods. This has led to research into transparent ceramics to satisfy the requirements of larger, more powerful solid-state lasers. AFOSR has led the Department of Defense in collaborating with leading laboratories in Japan involved with the development of transparent ceramics. Through this collaborative effort, which began in 2005, power densities achievable with transparent ceramics have improved from 1kW/cm³ to 1.2MW/cm³ in 2012. Advanced processing techniques developed by World Labo, Ltd, are taking ceramic powders and turning them into composite laser waveguides capable of high power densities with excellent thermal characteristics. These materials are enabling the next generation of solid-laser systems. This engagement with laser gain material fundamental research paves the path to higher efficiencies, thus enabling future military applications at light speed.

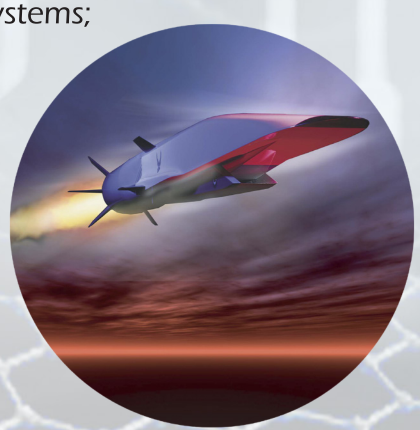
Organizational Structure and Technical Focus

Technology Horizons: Among the many areas of science and technology called out for emphasis, the two given highest priority were autonomous systems and enhanced human performance/human-machine interaction. Autonomous-systems research retains strong support with AFOSR, with one portfolio focusing on it and others supporting it. Support for human performance and integration with machines has expanded, including reshaping the sociocultural portfolio.

Energy Horizons: Energy storage and generation remain small parts of AFOSR's overall portfolio. We decided to invest in the few areas that need our funds, such as high-temperature superconductivity, and decided to watch developments coming from agencies that invest large amounts in research in the associated fields. The Department of Energy is, of course, the main funder. Strong programs are also in place in the Army and Navy and the National Science Foundation, and for challenges specific to the Air Force, at the 6.2 and higher levels. We note that although innumerable opportunities exist to advance the Air Force's storage and use of energy, the future for energy supply appears to be decidedly more optimistic than when Energy Horizons was released.

Cybervision 2025: Among the many fields this document recommends for increased effort were software (including validation and verification), quantum methods, and social computing. AFOSR reinvigorated and reshaped its software portfolio and continues to invest strongly in quantum sciences. Social computing falls within existing portfolios and continues to receive significant support from the International Office.

Global Horizons: Global Horizons was released only a few months before this document was written. There has been too little time for it to affect AFOSR's overall portfolio significantly. The main subjects it covers—materials science, biotechnology, autonomous systems, knowledge discovery, and social technologies—are all supported by AFOSR.



Other Air Force guidance: The Air Force Science & Technology Plan 2011 lists the following subjects for increased effort, largely in 6.2 and 6.3 research and development: improve the sustainment, affordability and availability of legacy systems; reduce cyber vulnerabilities while emphasizing mission assurance; support the needs of the nuclear enterprise; develop the autonomous system technologies envisioned in "Technology Horizons;" develop human performance augmentation technologies envisioned in "Technology Horizons;" provide robust situational awareness to enhance decision-making; enable long-range precision strike; and reduce energy dependency. Each of these subjects is addressed substantively in AFOSR's current portfolio and its plans. Recently published "Global Vigilance, Global Reach, Global Power for America" notes that the core functions of the Air Force have remained essentially unchanged since its inception:

Air and Space Superiority
Intelligence, Surveillance, and Reconnaissance
Global Mobility
Global Strike
Command and Control

It states "What has radically changed is how the Air Force performs these missions." Informed by the current set of missions, AFOSR discovers and supports research that can lead to further radical changes in how the Air Force will perform its missions.

DOD: Lists of six or seven technologies on which to focus were released. The list from ASD(R&E) maps better to 6.1 research: metamaterials, nanotechnology, quantum information processing, synthetic biology, cognitive neuroscience (brain science), and social technologies. All appear in one or more AFOSR portfolios, but we have not ramped up significantly in subjects that already receive strong support from other agencies. There are large national initiatives in nanotechnology, synthetic biology, and brain science. AFOSR helped launch the fields of metamaterials and quantum information science and it continues to support them. Social technologies offer immense promise, and AFOSR recently restructured the portfolios that address them.

The subjects in which AFOSR plans to invest are described in considerable detail in our Broad Agency Announcements. The main one—Research Interests of the Air Force Office of Scientific Research¬—and a number of narrowly focused ones are updated and released yearly. They can be found at:

http://www.wpafb.af.mil/afrl/afosr/

These announcements indicate the decisions made based on guidance, input from colleagues and innumerable technical sources, and our assessments of opportunity. More details on the plans of the five Arlington-based Departments follow.

Dynamical Systems and Control Department (RTA)

The Dynamical Systems and Control Department leads for AFOSR the discovery and development of the fundamental and integrated science that advances future air and space flight. Its broad goal is to discover and exploit the critical fundamental science and knowledge that will shape the future of aerospace sciences. Emphasis is placed on establishment of the foundations necessary to advance integration or convergence of the scientific disciplines critical to maintaining technological superiority.

The central research direction for this division aims at meeting basic research challenges related to future air and space flight. Programs center on mathematics, fluid flow and control, and structural mechanics and prognosis. In addition, the Test and Evaluation portfolio supports these subjects and enabling materials, hypersonics, sensors and electromagnetics, and information and data fusion.

Mathematics: The goals of portfolios in this subject include discovering mathematical algorithms and developing computational techniques that provide more-accurate, reliable, and efficient algorithms for modeling and simulation and design of complex systems for the Air Force, with radical cost and turn-time improvements; developing optimization and discrete mathematics for solving large, complex problems in support of future Air Force science and engineering, command and control systems, logistics, and battlefield management; and developing mathematical theory and algorithms based on the interplay of dynamical systems and control theories with the aim of developing innovative synergistic strategies for the design, analysis, and control of AF systems operating in uncertain, complex, and adversarial environments.

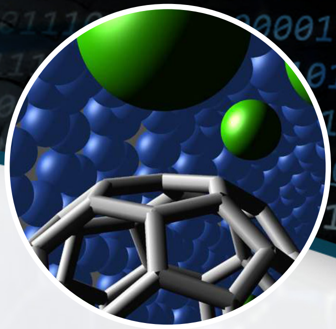
Because of recent advances in the field and per compelling needs identified by the Air Force, the subjects

Organizational Structure and Technical Focus

of multiscale/multiphysics approaches, the mathematics of uncertainty, handling dynamic data streams, while incorporating autonomous learning, distributed multi-agent control under constrained conditions, including pursuit and surveillance, quantum control and vision-based control, and human-robot teams are being expanded. Each of the decisions to expand follows guidance from Technology Horizons, Global Horizons, and DOD. Success in these new efforts will enhance greatly the fidelity with which we can compute real-world scenarios.

Flow Interactions and Control: The goals of these portfolios include supporting foundational research examining aerodynamic interactions of laminar/transitional/turbulent flows with structures, rigid or flexible, stationary or moving; and, at the intersection of gas dynamics, thermophysics, and chemistry, understanding and predicting energy transfer between the kinetic, internal, and chemical modes and to exploit this knowledge to shape macroscopic flow behavior. Fundamental understanding is used to develop integrated control approaches to intelligently modify the flow interaction to some advantage. Subjects receiving increased emphasis include looking to the natural world for insight into expanding our knowledge of aerodynamics, multiphysics-based studies, new studies on fine-scale surface effects, and the science and challenges of flight to speeds greater than Mach 10. The goals and subjects for growing support match well guidance from Technology Horizons, Energy Horizons, and Global Horizons.

Structural Mechanics and Prognosis: This portfolio focuses on computation of deformations, deflections, and internal forces or stresses within structures, either for design or for performance evaluation of existing structures. Future Air Force needs drive this portfolio toward emphasis on novel, enabling structures, multiscale modeling and prognosis, and complex structural dynamics. Consistent with advances in algorithms and computational power, modeling and prediction studies have expanded.



Quantum and Non-Equilibrium Processes Department (RTB)

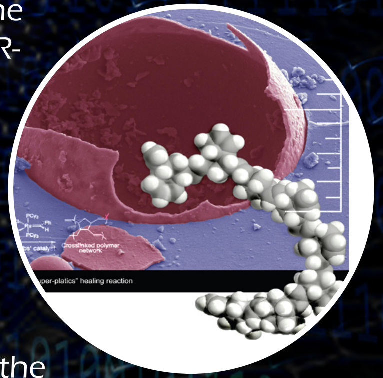
This division leads the basic research that generates the fundamental knowledge needed to advance U.S. Air Force operations, both from the perspective of sensing, characterizing, and managing the operational environment, as well as developing advanced devices that exploit novel physical principles to bring new capabilities to the Air Force. Core research of enduring importance to the Air Force is categorized in three broad areas:

Fundamental Quantum Processes: This includes exploration and understanding of a wide range of atomic, molecular, and optical phenomena, including strongly coupled electronic phenomena that occur in complex materials in all physical phases.

Plasma Physics and High Energy Density Nonequilibrium Processes: This area includes a wide range of activities characterized by processes that are sufficiently energetic to require the understanding and managing of plasma phenomenology, including the nonlinear response of materials to large electric and magnetic fields.

Optics and Electromagnetics: This area considers all aspects of producing, modifying, and receiving complex electromagnetic and electro optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Programs identified for enhancement because of recent cutting-edge scientific breakthroughs and potential impact on AF future capabilities are Ultrashort Pulse Laser-Matter Interactions, Quantum Information Science, and Biophysics.

Touch-sensitive plastic skin heals itself



In the last decade, there have been major advances in synthetic skin, but even the most effective self-healing materials had major drawbacks—until now. An AFOSR-funded team of Stanford chemists and engineers created the first synthetic protective barrier material that is sensitive to touch, capable of healing itself quickly and repeatedly at room temperature, and can also send the brain precise information about pressure and temperature. The researchers succeeded by combining two ingredients to get the self-healing ability of a plastic polymer and the conductivity of a metal; a plastic consisting of long chains of molecules joined by hydrogen bonds — the relatively weak attractions between the positively charged region of one atom and the negatively charged region of the next–these dynamic bonds allow the material to self-heal. The molecules easily break apart, but then when they reconnect, the bonds reorganize themselves and restore the structure of the material after damage occurs. To this resilient polymer, the researchers added tiny particles of nickel, which increased its mechanical strength. The result was a polymer with uncommon characteristics. Whereas most plastics are good insulators, this is an excellent conductor. The result: a self-healing "skin" that is far closer to the original than any previous effort.

Ultrashort pulse (USP) laser-matter interactions research focuses on the most fundamental process in nature, the interaction of light with the basic constituents of matter. Research explores opportunities accessible by means of the three key distinctive features of USP laser pulses: high peak power, large spectral bandwidth, and ultrashort temporal duration. The high peak powers allow techniques for novel material processing (e.g., machining, patterning), intense laser pulse atmospheric propagation, and concepts for sources of secondary photons (e.g., X-rays), and particle beams. The large spectral band-widths make USP lasers suitable for applications requiring high temporal and spectral precision, such as telecommunications, optical clocks, time and frequency transfer, spectroscopy, and arbitrary waveform generation. Lastly, light pulses of ultrashort duration allow for stroboscopic probes aimed at resolving attosecond electronic motion.

Quantum information science (QIS) research utilizes entirely novel quantum resources that were simply not experimentally accessible before, such as quantum superposition and entanglement. It is now possible to generate, manipulate, control, and measure these particular quantum states in various physical platforms. QIS will enable a range of exciting new capabilities for the Air Force, including: a revolutionary computational paradigm that will likely lead to the creation of computing devices capable of efficiently solving problems that cannot be solved on a classical computer; ultra-secure communication capabilities; greatly improved sensors with potential impact for precision

Organizational Structure and Technical Focus

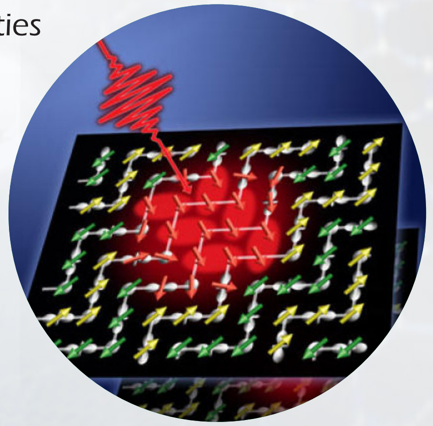
navigation, underground structure search, and improved radar imaging; discovery of novel materials and new phases of matter with extraordinary properties, such as supersolids.

Biophysics research seeks insights into physics by studying biological problems. The field of biophysics has produced spectacular insights into the interactions within cellular systems and into how these interactions are regulated. AFOSR biophysics research includes, but is not limited to, negentropy, stochastic processes (covering dynamics), bio-molecular imaging, bioelectricity, electromagnetic stimulation, electronic communications, and quantum biology. The focus of AFOSR's biophysics research is not simply to better understand the physics of biological system, but to gain an understanding of this physics that may be exploited for novel solutions to known challenges. Potential impacts include the design and operation of new computers based on knowledge garnered from bioelectricity and quantum biology research and the ability to image materials below the diffraction limit, without destroying the material.

Information, Decision, and Complex Networks Department (RTC)

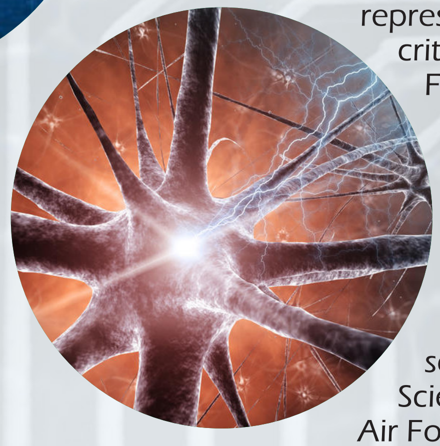
The Information, Decision, and Complex Networks Department support directly many Air Force priorities, including air and space situational awareness, autonomy, command and control, and cyber systems. Key questions it addresses are how well-understood and structured are the data in the problem and how interdependent, heterogeneous, and dynamic is the problem? The programs in the division cluster into three sets of portfolios: information, decision making, and complex networks.

Information: The Air Force faces ever more need to collect, analyze, explicate, and disseminate large quantities of information rapidly, while assuring secure operation of all systems. The information portfolios enable the ability to collect, disseminate, and integrate information through mathematical characterization and assessment the most appropriate information for a range of mission-critical tasks; to develop algorithms to collect and decompose critical sensing information and enable techniques that bridge physical domains such as electromagnetics and methods in navigation; to analyze and exploit the interplay between physical and software systems; to examine fundamental issues for assessing systems in terms of secure operations and mission; and to assess information systems from a verification and validation standpoint to guarantee operations under a variety resource constraints. Emphases include studies of big data, high-dimension data, fast approximations, integration of multiple techniques, synthesis of reasoning and computing, and merging of quantitative and qualitative models. All are called out in CyberVision 2025 and elsewhere. Guidance within Technology Horizons and Global Horizons motivated and motivates selection of the topics of for growing investment in the portfolios focused on dynamical systems.



Decision Making: This thrust focuses on discovery of mathematical laws, foundational scientific principles, and new, reliable, and robust algorithms that underpin mixed human-machine decision making to achieve accurate real-time projection and use of knowledge and expertise by the Air Force. Subjects of focus include machine and human cognition and learning, the primary objective of which is to maximize the ability of machines to conduct higher-level cognitive activities with quantifiable risk, and measuring and modeling how of individuals make decisions and are influenced both in small groups and culturally. Topics receiving increased investment include neuro-computational cognition, bio-inspired computing machines, robust decision-making and classification, trust in autonomous systems, human-like robot interactions, and influence effects (including of weapons on populations). These subjects were called out in Technology Horizons and Global Horizons.

Complex Networks: This thrust area focuses on mathematically representing networks of all kinds, including communications and computation at all levels of content, protocol, and architecture. This mathematically unified representation is meant to measure, represent, resource, and secure critical infrastructures for Air Force and DOD applications. The thrust also aims to use measurements and representations to verify and validate critical infrastructure performance. Advances in network sciences, as called out in several reports from the Chief Scientist, will be crucial to future Air Force operations.



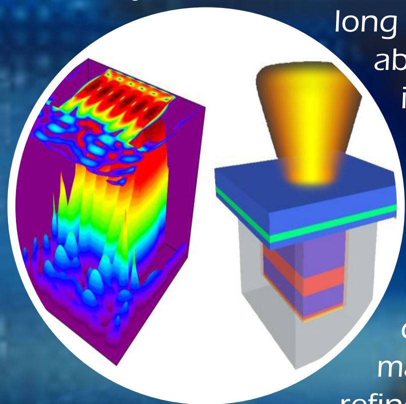
Complex Materials & Devices Department (RTD)

This division leads the discovery and development of the fundamental and integrated science that provides novel options that increase operational flexibility and performance relevant to the Air Force. A key emphasis is the establishment of the foundations necessary to advance the integration or convergence of the scientific disciplines critical to maintaining technological superiority. The Department carries out its ambitious mission through the leadership of a global, multidisciplinary research community to identify research to support and foster new scientific discoveries that will ensure future innovations to transform the Air Force of the future.

The Complex Materials & Devices Department focuses on meeting the basic research challenges by leading the discovery and development of fundamental science and engineering across materials, devices, and systems:

Structural and Functional Materials: The focus is on complex materials, microsystems and structures by incorporating hierarchical design of mechanical and functional properties from the nanoscale through the mesoscale, ultimately leading to controlled well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. The research thrust areas include, but are not limited to, high-temperature materials, low-density load-bearing materials, smart/active materials, electronic materials, optical materials, optoelectronics, metamaterials, dielectric and magnetic materials, new classes of high-temperature superconductors, quantum dots, quantum wells, and two-dimensional and three-dimensional materials. Wide ranges of activities and environments dictate processes sufficiently energetic to require understanding of nonlinear responses of materials to combined loads under high-energy-density, non-equilibrium extremes. The research thrust also covers multidisciplinary approaches for studying, using, mimicking, or altering the novel ways that biological systems accomplish their required tasks.

Electrically Powered Nanolasers Capable of Operating at Room Temperature



Co-funded by AFOSR and DARPA, a team at Arizona State University accomplished something that may result in a solution to keep Moore's Law on track. Moore's Law is the prediction that, over the long term, the number of transistors embedded on integrated circuits would double about every two years. Shrinking the size of lasers is crucial to integrating photonic with electronic components as they become not only smaller, but faster. By placing more lasers into the same space, far greater processing speeds are attained—which makes possible the next generation of computers. Previous experiments have failed due primarily to overheating. What was different this time came down to a matter of thickness–when the team refined the fabrication process and adjusted the thickness of the silicon nitride layer, the heat dissipated far faster—and kept the nanolaser in continuous operation. This success will have a significant impact on the further development and integration of nanolasers as it addresses thermal issues and the role of metals in such nanostructures. Ultimate solutions to such difficult problems will pave the road toward full integration of photonic and electronic micro and nanoscale components for use in various practical applications.

Devices and Systems: In addition to research into underlying materials and fundamental physical processes, this area considers how they might be integrated into new classes of devices and pursues a fundamental understanding of materials that are not amenable to conventional computational means. Efforts include exploration and understanding of a wide range of complex engineered systems and devices, including chip-scale optical networks, high-frequency/high-speed and low-power-consumption devices, integrated electronics and photonics, multi-functional/autonomic/self-sustaining systems, and reconfigurable systems. This topic includes the discovery of how to mimic existing natural sensory systems, and adds existing capabilities to these organisms for more precise control over their material production.

Energy, Power and Propulsion Sciences Department (RTE)

This division seeks to discover, develop, and transition critical basic research that will foster innovation and revolutionary concepts enabling greater operational efficiency and reduced resource consumption. The envisioned impacts of this research include, but are not limited to, advancements that allow enhanced performance for a given energy input or maintained capability with greatly reduced energy investment. Examples of the application of such advancements include increased fuel efficiency, range, and payload for aerospace systems; improved energy yield per mass and controlled energy extraction from new materials and chemical compounds; and identification and

Organizational Structure and Technical Focus

development of advanced propulsion concepts yielding greater specific thrust or reduced fuel consumption, as well as alternative fuel sources.

The research interests and accomplishments of this division are strongly aligned with the recent national emphasis on the development of hypersonic capabilities. The division is the national leader in the development of relevant basic science. In this regard, the division has led the development and sustainment of the National Hypersonic Foundational Research Plan, which coordinates the efforts of the Air Force, NASA, and the Department of Energy, and has been adopted as the DOD basic research plan for hypersonics. Additionally, the transition of maturing basic research capabilities developed by the division to application in major technology demonstration programs within the Air Force and DARPA has transformed the industrial state of the art in the prediction of aerothermodynamic heating and has led to unprecedented new capabilities to resolve critical phenomena within the Test and Evaluation community. A current initiative that integrates contributions from a number of portfolios focuses on the discovery, characterization, and exploitation of rate-dependent energy transfer processes in the interaction between a responsive material surface and the extreme conditions of a hypersonic flow.

The research interests are classified into two broad areas: energy extraction and storage; energy conversion and utilization. Additionally, the research elements within RTE play a critical role in leading national scientific efforts to realize hypersonic and biology/neuroscience-derived capabilities.

Energy Extraction and Storage 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 nanoenergetic particles. Specific portfolios with significant investments in this area are Molecular Dynamics and Theoretical Chemistry, Dynamic Materials and Interactions, and Human Performance and Biosystems, with examples of prioritized research themes including Nanostructures and Catalysis, Energetic Materials, and Photo-Electro-Magnetic Bio-stimulation.

Future research in this area will explore the critical dynamics of transient molecular-, micro- and meso-scale phenomena within complex materials under extreme conditions.

Energy Conversion and Utilization addresses the characterization, modeling and optimization of dynamic processes that represent energy transfer within systems of interest to the Air Force. Major areas of emphasis include fundamental energy conversion mechanisms of combustion in systems, ranging from small unmanned air systems to scramjets, rocket motors, and space micro-thrusters, along with the identification of fundamental mechanisms of energy transfer between kinetic, internal, and chemical modes in the aerothermodynamic flows around high-speed air and space vehicles. Specific portfolios with significant investment in this area include Aerothermodynamics, Energy Conversion and Combustion Sciences, and Space Power and Propulsion, with examples of prioritized research themes including Combustion Physics, Nonequilibrium Processes, and Shock-Dominated Flows.

Future research will examine key energy transfer pathways in combustion and nonequilibrium flows will shape the emergence of new possibilities for flow control and enhanced propulsion efficiency.

Basic Research Programs

University Research

Intramural Basic Research

Small Businesses

International Involvement

Future U.S. Technology Workforce

For over 60 years, AFOSR has expanded scientific knowledge by identifying, supporting, nurturing, and transitioning basic research opportunities. AFOSR has to date sponsored 73 scientists and engineers who have earned Nobel Prizes in physics, chemistry, medicine, or economics. AFOSR's basic research investments are executed primarily with U.S. universities and the other AFRL Technology Directorates, but critical components also occur within businesses, international organizations, and other Federal agencies. This section provides an overview of the primary AFOSR programs and funding mechanisms.

University Research

Single-Investigator Grants: AFOSR awards grants to single university researchers pursuing revolutionary scientific breakthroughs in subjects that are identified via its broad agency announcements. These researchers typically are university professors leading small teams of graduate students and postdoctoral associates. Businesses and a broad range of research laboratories are also eligible for single-investigator awards.

Young Investigator Program (YIP): The YIP supports scientists and engineers who have received Ph.D. or equivalent degrees within the previous five years and show exceptional ability and promise for conducting basic research. The objectives of this program are to foster creative basic research in science and engineering, to enhance early career development of outstanding young investigators, and to increase opportunities for young investigators to incorporate the Air Force mission and related challenges in science and engineering into their professional activities and plans.

Multidisciplinary University Research Initiative (MURI): MURI grants complement single-investigator awards by investing in research at the intersections of multiple science and engineering disciplines. Such multidisciplinary research teams, often involving multiple universities, accelerate research progress through the cross fertilization of scientific disciplines.

Defense University Research Instrumentation Program (DURIP): DURIPs provide equipment grants to universities to enhance current research capabilities or develop new ones to support research of Air Force interest.

University Centers of Excellence: A University Center of Excellence (CoE) is defined as a joint effort among AFOSR, at least one AFRL Technology Directorate, and an outstanding university or team of universities to perform high-priority collaborative research. A CoE should extend the research capabilities of AFRL and provide opportunities for a new generation of U.S. scientists and engineers to address Air Force research needs.

Intramural Basic Research

Laboratory Research Independent Research Program: AFOSR invests in basic research at the AFRL Technology Directorates to address significant scientific challenges and to develop in-house capabilities and the technical workforce. Laboratory researchers typically are single investigators or senior investigators leading small teams of government scientists, postdoctoral associates, and on-site research contractors.

Resident Research Programs: AFOSR manages and co-funds the National Research Council Resident Research Associates (NRCRRA) program and the Summer Faculty Fellowship Program (SFFP). The NRCRRA provides postdoctoral (more than five years since Ph.D.) research fellowships of one to three years at Air Force research sites. The SFFP supports academic faculty to conduct on-site research in collaboration with Air Force researchers during the summer months. These two programs provide opportunities to bring new expertise to AFRL and to enhance professional relationships among Air Force and university researchers.

Visiting Scientist Program: AFOSR manages the Visiting Scientist Program, which provides outstanding U.S. Air Force scientists and engineers with opportunities to conduct for an extended period full-time, hands-on research activities in leading U.S. universities or industrial laboratories. This program is designed to enhance the research careers and develop the skill sets of Air Force scientists and engineers.

Small Businesses

AFOSR manages the Air Force Small Business Technology Transfer (STTR) program. The STTR program is designed to transition ideas from research institutions to the commercial sector, where the technology can benefit the Air Force and the nation as a whole. This program is similar to the Small Business Innovative Research (SBIR) program, but requires official collaboration with a U.S. university, federally funded research and development center, or nonprofit research institution.

Revolutionary "Green" Spacecraft Propellant

In 2015, NASA, for the first time, will fly a space mission utilizing a radically different propellant- one which has reduced toxicity and is environmentally benign. This energetic ionic liquid, or EIL, is quite different from the historically employed hydrazine-based propellant, which has significant drawbacks: it is very toxic when inhaled, corrosive on contact with skin, hazardously inflammable, and falls short in providing the propulsive power required for future spacecraft systems. In 1998, AFOSR funded research at the Propellants Branch at the Rocket Propulsion Division at AFRL's Aerospace Systems Directorate, to find a more benign, yet even more powerful material to replace hydrazine. Their efforts were ultimately associated with a joint government and industry development program, the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) initiative, to improve U.S. rocket propulsion systems. With support from IHPRPT, the Missile Defense Agency (MDA) and related USAF missile programs, a full characterization of a new propellant class, AF-M315E, was completed. The result: the AFOSR- funded program provided the synthesis and characterization work for an EIL that enabled the experimental USAF fuel, AF-M315E, to act as a high-energy density, environmentally benign, easy-to-handle replacement for spacecraft hydrazine fuel. As EIL-based propellants are developed, they will provide lower cost and safer propulsion system operations along with greater mission flexibility and faster mission response times.

Basic Research Programs

International Involvement

Single-Investigator Grants and Contracts: AFOSR's International Office makes awards to foreign researchers. As with its domestic awards, most go to universities and the main goal is to support research with potential for revolutionary breakthroughs. Awards are also made in support of conferences and workshops, which are key elements of AFOSR's international engagement.

People Programs: Information exchange among leading researchers is at the heart of successful international engagement. AFOSR's International Office manages a variety of programs designed to facilitate sharing of information and to promote collaboration. The Windows-on-Science Program provides support for foreign researchers to visit Air Force researchers for one to a few days. The Windows-on-the-World Program supports AFRL researchers to work at foreign sites for a number of weeks or months. The Engineer and Scientist Exchange Program places AFRL researchers into foreign government laboratories and foreign government researchers into Air Force laboratories for periods of up to two years.

International Partnerships: Concentrating international engagement on a specific country or region may under some circumstances accelerate research advances and impart significant benefits to AFRL. In such cases, the International Office can promote partnering through a variety of mechanisms. It is often found that partnering with, for example, another country's research funding agency requires consistent close coordination, but no influx of additional funds.

Future U.S. Technology Workforce

The technological superiority of the Air Force depends on the availability of experienced, well-trained scientists and engineers. AFOSR's basic research grants and contracts support each year approximately 2,000 graduate students and postdoctoral associates working under the mentorship of outstanding university researchers. Through our Historically Black Colleges/Universities and Minority Institutions program, we not only support quality research, but also increase the number of minority graduates in the fields of science, engineering, and mathematics important to the Air Force. We also participate in DOD programs specifically targeted at attracting graduate students and undergraduate students working in research fields of interest to the DOD and the Air Force.

National Defense Science and Engineering Graduate (NDSEG) Fellowship Program: The NDSEG Fellowship Program is sponsored by AFOSR, the Army Research Office, the Office of Naval Research, and the DOD High Performance Computing Modernization Program. The NDSEG program provides three-year fellowships to U.S. citizens or U.S. nationals pursuing Ph.D.s in science and engineering disciplines of importance to DOD.

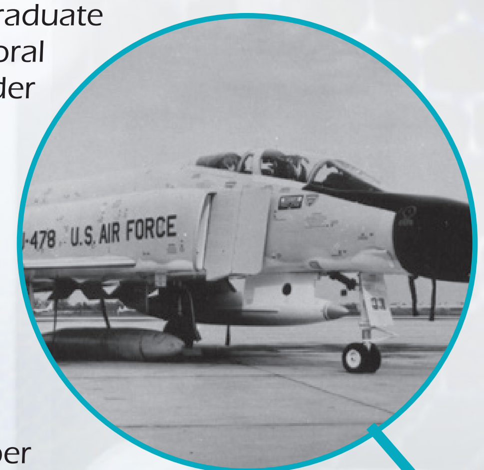
Awards to Stimulate & Support Undergraduate Research Experiences (ASSURE) Program: The ASSURE program supports undergraduate research in DOD-relevant disciplines and is designed to increase the number of high-quality undergraduate science and engineering majors who ultimately decide to pursue advanced degrees in these fields. The ASSURE program emphasizes involvement of students who might not otherwise have access to such research opportunities.

Keeping the Plan Current

AFOSR's Technical Strategic Plan is intended to guide present activities and future planning. It explains what AFOSR is as a scientific organization and what it strives to be. To be fully effective, AFOSR's structure and processes and this plan must be reviewed and updated periodically. Some inputs into AFOSR's plans arrive throughout the year; research progresses and is assessed, new guidance is promulgated, budgets change, other agencies announce results and plans, throughout the world new entities are created and new initiatives are launched.

The Departments within AFOSR are examined for number, technical focus, programmatic output, and personnel on a yearly basis. Included in the decision-making processes are gathering and analysis of scientific and budgetary metrics. Adjustments are made, as appropriate. In addition to in-house reviews and studies, AFOSR continues to rely on expert advice. Its Scientific Advisory Board meets every two years and various studies and panels are convened to provide AFOSR with independent advice on its status and future.

To remain current and seminal, AFOSR's Technical Strategic Plan is examined in detail yearly. It is rewritten when necessary. We expect significant updates to this plan to be required every two to four years.



Nobel Prize Winners

AFOSR has sponsored 73 researchers who went on to become Nobel Laureates. On average, these Laureates received AFOSR funding 17 years prior to winning their Nobel awards.

1955 PHYSICS
Polykarp Kusch, Willis Lamb

1956 PHYSICS
John Bardeen

1960 CHEMISTRY
Willard Libby

1961 PHYSICS
Robert Hofstadter

1963 PHYSICS
Eugene Wigner

1964 PHYSICS
Charles Townes

1966 CHEMISTRY
Robert Mulliken

1967 MEDICINE
Ragnar Granit

1967 PHYSICS
Hans Bethe

1967 CHEMISTRY
George Porter

1968 CHEMISTRY
Lars Onsager

1969 PHYSICS
Murray Gell-Mann

1970 MEDICINE
Ulf von Euler

1972 PHYSICS
John Bardeen, John Schrieffer

1973 PHYSIOLOGY/MEDICINE
Nikolass Tinbergen

1973 PHYSICS
Brian Josephson

1974 CHEMISTRY
Paul Flory

1976 CHEMISTRY
William Lipscomb

1977 PHYSICS
Philip Anderson, John Van Vleck

1977 CHEMISTRY
Ilya Prigogine

1978 ECONOMICS
Herbert A. Simon

1979 PHYSICS
Sheldon Glashow, Steven Weinberg, Abdus Salam

1980 CHEMISTRY
Walter Gilbert

1981 PHYSICS
Nicolas Bloembergen, Arthur Schawlow, Kai Siegbahn

1981 CHEMISTRY
Kenichi Fukui, Roald Hoffman

1981 MEDICINE
David Hubel, Thorsten Wiesel

1983 PHYSICS
Subramanyan Chandrasekhar, William Fowler

1986 CHEMISTRY
Yuan Lee, Dudley Herschbach, John Polanyi

1987 CHEMISTRY
Donald Cram

1988 PHYSICS
Melvin Schwartz

1990 CHEMISTRY
Elias Corey

1990 PHYSICS
Jerome Friedman, Henry Kendall

1992 CHEMISTRY
Rudolph Marcus

1995 CHEMISTRY
Mario Molina

1996 CHEMISTRY
Richard E. Smalley

1997 PHYSICS
Steven Chu

1998 PHYSICS
Daniel Tsui

1999 CHEMISTRY
Ahmed Zewail

2000 CHEMISTRY
Alan Heeger, Alan G. MacDiarmid

2000 PHYSICS
Herbert Kroemer

2000 MEDICINE
Eric R. Kandel, Paul Greengard

2000 PHYSICS
Jack Kilby

2001 PHYSICS
Wolfgang Ketterle

2002 ECONOMICS
Daniel Kahneman

2002 CHEMISTRY
John Fenn

2003 PHYSIOLOGY/MEDICINE
Paul C. Lauterbur

2005 PHYSICS
John Hall, Roy Glauber, Theodor W. Hansch

2005 CHEMISTRY
Robert Grubbs

2005 ECONOMICS
Thomas Schelling

2006 PHYSICS
George Smoot

2008 PHYSICS
Yoichiro Nambu

2010 PHYSICS
Andre Geim, Konstantin Novoselov

2011 CHEMISTRY
Daniel Schechtman

2012 PHYSICS
David Wineland

2013 Physics
Peter Higgs, Francois Englert

References

Air Force:

Global Vigilance, Global Reach, Global Power for America (United States Air Force, 2013)

Global Horizons: United States Air Force Global Science and Technology Vision (United States Air Force Chief Scientist, 2013)

Air Force Materiel Command Strategic Plan 2013

Cyber Vision 2025: United States Air Force Cyberspace Science and Technology Vision 2012-2025 (United States Air Force Chief Scientist, 2012)

Energy Horizons: United States Air Force Energy S&T Vision 2011-2026 (United States Air Force Chief Scientist, 2012)

US Air Force Global Partnership Strategy 2011

Air Force Science & Technology Plan 2011 (Air Force Research Laboratory, 2011)

Bright Horizons ...the Air Force STEM Workforce Strategic Roadmap (Secretary of the Air Force, 2011)

Technology Horizons: A Vision for Air Force Science & Technology During 2010-2030 (United States Air Force Chief Scientist, 2010)

Air Force Science & Technology Strategy 2010

Other DOD:

Report of the Defense Science Board Study on Technology and Innovation Enablers for Superiority in 2030 (2013)

Sustaining U.S. Global Leadership: Priorities for 21st Century Defense (Secretary of Defense, 2012)

Report of the Defense Science Board Task Force on Basic Research (2012)

Statement Testimony, The Honorable Zachary J. Lemnios, Assistant Secretary of Defense for Research and Engineering Before the United States House of Representatives Committee on Armed Services, Subcommittee on Emerging Threats and Capabilities (2012)

2012 U.S. Marine Corps S&T Strategic Plan

U.S. Army Research Laboratory Annual Review 2012

U.S. Army RDECOM Strategic Plan FY2012 - FY2019
Science and Technology (S&T) Priorities for Fiscal Years 2013-17 Planning (Secretary of Defense, 2011)

Naval S&T Strategic Plan (Office of Naval Research, 2011)

National Defense Strategy (Department of Defense, 2008)

Department of Defense Research & Engineering Strategic Plan (Director of Defense Research & Engineering, 2007)
Strategic Plan: Defense Advanced Research Projects Agency (2007)

International Science and Technology Strategy for the United States Department of Defense (Defense Research & Engineering, 2005)

Other USA:

NIST Three-Year Programmatic Plan, FY 2014-2016 (2013)

Global Trends 2030: Alternative Worlds (National Intelligence Council, 2012)

A Strategy for American Innovation: Securing Our Economic Growth and Prosperity (The White House, 2011)

Empowering the Nation through Discovery and Innovation: NSF Strategic Plan for Fiscal Years 2011-2016 (2011)

2011 NASA Strategic Plan

U.S. Department of Energy Strategic Plan 2011
Assessment of Department of Defense Basic Research (National Research Council, 2005)


AFOSR