AFOSR Mission

*Discover, shape, and champion basic science that profoundly impacts the future Air Force*

- ID Breakthrough Research Opportunities – Here & Abroad
- Foster Revolutionary Basic Research for Air Force Needs
- Transition Technologies to DoD and Industry
Goals for AFOSR to strengthen the Air Force basic research program as defined in AF S&T Strategic Plan:

- Provide scientific leadership for the AF basic research enterprise
- Attract the Nation’s/World’s best S&Es to contribute to and lead AF/DoD research
- Ensure the coherence and balance of the AF basic research portfolio
- Foster connections between AFRL researchers and the National/International basic research community
- Maximize the discovery potential of the defense research business environment

Focus on the Future AF with the ultimate goal to make Today’s AF and Tomorrow’s AF Obsolete!
AFOSR Supports AFRL Core Technical Competencies (CTC)

RV – Develop electro-optical sensors & inertial navigation on chip

RI – Develop robust cyber command and control system

RH – Discover & quantify size, shape, motion & molecular signatures indicative of threat

RX - Develop new alloy and tailor micro-structure for turbine blade

RY – Develop new radio frequency and optical metamaterial device and components

RZ – Development of scramjet propulsion

RW - Developing new fuse and sensors technologies

RD - Higher-quality image restorations. Enhanced using adaptive-optics research
AFOSR FY12 Budget Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 2011</th>
<th>FY 2012</th>
<th>FY 2013*</th>
<th>FY 2014*</th>
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<td>61102F (Core)</td>
<td>348,910</td>
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International, $10,937,539
Tax (AF, AFRL, CGR), $38,072,276
AFOSR Support/Overhead, $35,792,218
AFRL (LRIR, CS, ST), $62,541,416
Extramural Research, $193,134,092
Workforce (Post-Doc, SFFP, Center of Exc.(CoE), Other), $23,850,459

* Estimate

$86M (unburdened)
AFOSR Roles: AF Basic Research Manager

- Identify Breakthrough Research Opportunities – Here & Abroad
  - Regular interactions with leading scientists and engineers
  - Int’l offices in Europe, Asia, Latin America
  - 54 workshops conducted; 105 conferences co-sponsored

- Foster Revolutionary Basic Research for Air Force Needs
  - 1358 extramural research grants at 228 U.S. universities
  - 309 intramural research projects at AFRL, USAFA, AFIT
  - 590 fellowships; 2894 grad students, 603 post-docs on grants

- Transition Technologies to DOD and Industry
  - AFRL TDs represent the principal transition path
  - 169 STTR small business - university contracts
  - 907 funded transitions (follow-on-uses) from FY11 PI data call
AFOSR Ten Focus Areas

(AFY12 - $364.3M)

Aerospace, Chemical & Material Sciences
- Aero-Structure Interations & Control
- Energy, Power & Propulsion
- Complex Materials & Structures

Physics & Electronics
- Complex Electronics & Fundamental Quantum Processes
- Plasma Physics & High Energy Density
- Optics, EM, Comm, Signals Processing

Mathematics, Information & Life Sciences
- Info & Complex Networks
- Decision Making
- Dynamical Sys, Optimization & Control
- Natural Materials & Systems

University Research Initiatives

(FY12 - $140.3M)
Model-free simulations of >Mach 3 shock turbulent boundary layer interactions

Aero-Structure Interactions and Control:
- Turbulence and laminar-turbulent transition
- Unsteady aerodynamics and flow control
- Aero-elasticity and structural dynamics
- Integrated Modeling

Energy, Power and Propulsion:
- Novel energetic materials
- Combustion and catalysis chemistry
- Thermal science
- Novel means of producing, collecting and storing energy
- System-level analysis and modeling

Complex Materials and Structures:
- Novel lightweight materials
- Materials with tunable properties
- Reconfigurable structures
- Multifunctional materials and structures

Application of a nanotube sheet as a mirage based concealment cloak is demonstrated in water.

Time Magazine List of Best Inventions for 2011
• **Micro-Robotic Fly**: Research to understand how wing design can impact performance for an insect-size, flapping-wing vehicle for monitoring & exploration.

• **Carbon-Neutral Fuels**: Develop new electrocatalysts to efficiently produce alcohols and carbon-carbon bonded products from CO\(_2\) and sunlight feedstocks.

• **Coating Resists Liquids**: Created a material that repels just about any type of liquid, including blood and oil, and does so even under harsh conditions like high pressure and freezing temperatures.
## Mathematics, Information & Life Sciences: Current Trends

### Information and Complex Networks:
- Science of cyber security
- Mathematics of complex networks
- Massive data and information
- Software/algorithms for advanced computational architectures

### Decision-Making:
- Robust computational intelligence
- Mathematical basis for neurobiological processes
- Trust, autonomy, and the human-machine interface
- Effect of culture on influence

### Dynamical Systems, Optimization and Control:
- Multiagent, networked control
- Contested environments
- Uncertain, information-rich, dynamic environments

### Natural Materials and Systems:
- Bio-inspired materials
- Bio-derived materials including energy
- Bio-sensing
- Extremophiles

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Math guarantees of performance for policy, protocol, and security using new coding, management, and online analysis methods.

Enabling distributed control of flexibly autonomous agents for performing single or multiple tasks and missions.
Mathematics, Information & Life Sciences

• Dynamic Information System Verification: Develop new mathematical algorithms for real time measurement, risk analysis, and statistical verification of large systems.

• Spider Silk Research: Created artificial spider silk that is stronger, flexible, and bio-degradable. Silk has unusual mechanical & optical properties for thin film devices or to improve body armor.

• Artificial Photosynthesis: This artificial leaf is a device that can harness sunlight to split water into hydrogen and oxygen without needing any external connection and in environmentally friendly conditions.
Physics & Electronics: Current Trends

Complex Electronics and Fundamental Quantum Processes:
- Ultracold Atoms & Molecules
- Metamaterials & Graphene
- Dielectric and Magnetic Materials
- High Temperature Superconductors
- Novel Sensing Devices and Architectures
- Non-linear Optical Materials, Optoelectronics, and Nanophotonics

Plasmas & High Energy Density Nonequilibrium Processes:
- Space weather
- High power microwave devices
- RF propagation and RF-plasma interaction
- Plasma discharges & non-equilibrium chemistry
- Cold, dense, degenerate plasmas
- Plasma control of boundary layers in turbulent flow

Optics, Electromagnetics, Communication, & Signal Processing:
- RF and EO signal processing
- Information fusion
- Lasers and non-linear optics, ultrashort pulse lasers
- Novel RF devices and communication architectures

Diocles laser, which produces the most intense light on earth.

Combining low-cost silicon chips with tiny lasers to send bits of data using light rather than pulses of electricity.
Physics & Electronics

- **Plasmonic Circuits**: New designs for passive components (inductor & resonator) in communication circuits and high-performance oscillators and tunable multi-spectral terahertz detector arrays.

- **Relativistic Magnetron**: Develop more compact magnetrons that operate at higher power and higher frequencies and those could be used to jam and defeat enemy electronics.

- **Terahertz Laser**: Advances in metamaterials may lead to a new semiconductor laser suitable for security screening, chemical/bio sensing, and astronomy.
AFOSR Research Focus Areas

FY11

Research Focus Areas

Funding Amount ($M)

- Aero-Structure Interactions and Control
- Complex Electronics and Fundamental Quantum Processes
- Complex Materials and Structures
- Decision Making
- Dynamical Systems, Optimization, and Control
- Energy, Power and Propulsion
- Information and Complex Networks
- Natural Materials and Systems
- Optics, Electromagnetics, Communication, and Signal Processing
- Plasma Physics and High Energy Density Nonequilibrium Processes

61102F  61103F
AFOSR Future Trends

- Increase:
  - ASD (R&E) disruptive basic research areas
  - Interface of mathematics, information, cyber, human, and physical modeling
    - Cyber/Software/Complex systems
    - Exploitation of massive data
    - Transformational computing
    - Trusted cyber and autonomy
    - Human performance enhancement
  - Materials and surfaces at high energy density
  - Designer materials (structural and functional)
- Decrease:
  - Bioenergy/Biofuels (other agencies are funding)
  - Thermosetting polymers/surface adherents (mature)
  - Adaptive, self-healing materials (mature)
  - Complementary metal–oxide–semiconductor (CMOS) (industry)
Future Research Activities

Math, Info, Cyber, Human, Physical
- Reliance optimization for autonomous systems
- Cyber trust and suspicion; trusted autonomy
- Design under uncertainty of complex engineering systems
- Dynamic data driven application systems
- Ultra-scale and fault-resilient algorithms
- Transformational computing via co-design of high-performance algorithms and hardware
- Bio-nanocombinatorics
- Foundations of energy transfer in multi-physics flow phenomena
- Layered structured 2D-materials for extreme environment
- High peak power, ultrashort laser ablation of solids
- Catalytic reactions in endothermic cooling systems
- Ultra-cold and strongly coupled plasmas
- Micro-resonator-based optical frequency combs
- Origami design for the integration of self-assembling systems
- Active, functional nanoscale oxides
- Autonomic material systems utilizing biomolecular transduction
- Sustainable alloy design: Rare earth materials challenge

High Energy Density

Designer Materials
Supporting Tomorrow’s S&Es

• **Presidential Early Career Award for Scientists & Engineers (PECASE)**
  — Recognizes outstanding young researcher
  — 5-year awards $200K/year

• **Young Investigator Program (YIP)**
  — Develops long-term relationships with junior PIs
  — 222 YIP awards since FY07; 48 awards in FY12

• **National Defense Science and Engineering Graduate Fellowship (NDSEG) Program**
  — Supporting 590 PhD-track graduate students in DoD relevant fields

• **Awards to Stimulate and Support Undergraduate Research Experience (ASSURE)**
  — Provides 550 undergraduates with research opportunities in S&E fields of DoD interest during summer months
AFOSR Supports University Individual Investigators

• Goals
  – Provide revolutionary scientific breakthroughs to maintain military air, space, and information superiority
  – Build collaborations between AFRL and universities

• General Process
  – Researchers submit white papers to AFOSR program managers
  – Promising white papers lead to request for full proposals
  – Proposals merit reviewed for excellence and relevance
  – Individual grants awarded for up to 5-years in duration

• Broad Agency Announcement (BAA) open at all times to innovative ideas http://www.afosr.af.mil
AFOSR Supports Multidisciplinary University Research (MURI)

- Achieve significant scientific advances
  - Capture attention of top researchers
  - Build on results of individual-researcher grants
  - Encourage multidisciplinary collaboration
- Up to $1.5M/yr for five years
- Typically 6 - 8 research topics per Service
  - Occasional joint topics
  - One or two awards per topic
Small Business (University-Industry) Collaborations (STTR)

- Small Business Technology Transfer (STTR) program provides up to $850,000 for early-stage R&D directly to small companies working cooperatively with research institutions (http://www.acq.osd.mil/sadbu/sbir/)
  - Company must be U.S. for-profit small business; 500 or less employees
  - Research institution must be a U.S. college or university, FFRDC, or non-profit research institution
  - Principal investigator must be employed at small business or research institution
  - Provides technology transition opportunities
  - FY11 funded amount was about $40M.
NRC Post-Doc & Summer Faculty

- **NRC Resident Research Associates (Post-Doc Program)** - $6.2M for current 73 Post-Docs
  - Offers postdoctoral and senior S&E opportunities to perform research at sponsoring TDs
- **Summer Faculty Fellowship Program (SFFP)** - $3.0M
  - Offers fellowships to university faculty and students to conduct research at AFRL in the summer (97 Faculty & 22 Grad Students)

100% increase in funding for Post-Doc and SFFP in FY13
• Defense University Research Instrumentation Program (DURIP)
  – Provides specialized research equipment to universities in support of DOD research
  – Up to $1M per grant; 48 awarded in FY10, median award $200K
  – 287 proposals received for FY2011 awards
National Security Science and Engineering Faculty Fellowships

• **DDR&E program, managed by AFOSR**
• **Objectives**
  - Excellent unclassified basic research on topics of interest to DoD
  - Long-term relationships with outstanding faculty and students
  - Familiarity with DoD missions, technologies, and challenges
  - Cadre of technical experts for DoD advisory groups
• **Award Information (Eleven awards in FY10)**
  - Single-investigator awards up to $850K/yr for up to 5 years
  - Open to faculty at US doctoral degree-granting institutions
  - US citizens and permanent residents are eligible to apply
• **Application process (more info at [http://nsseff.ida.org/](http://nsseff.ida.org/))**
  - Letter of intent to nominate from home institution
  - Formal nomination letter and white paper
  - Full proposal and oral presentation (by invitation only)
AFOSR International Enterprise

- Building international goodwill
- Strengthening partnerships
- Avoiding technological surprise
- Accelerating S&T achievements and transitions to the U.S.

AOARD
Asian Office of Aerospace Research and Development
Tokyo

EOARD
European Office of Aerospace Research and Development
London

SOARD
Southern Office of Aerospace Research and Development
Santiago

Total Funding (All Sources): $17.5M

- AOARD Internal, $6,326,039
- AOARD External, $3,129,000
- EOARD Internal, $4,996,980
- EOARD External, $1,363,114
- SOARD Internal, $1,008,210
- SOARD External, $712,202
- SOARD External, $712,202
Assure Quality Transitions

• Perform comprehensive scientific opportunity search
  – Meetings with numerous researchers – AFRL, elsewhere
  – Interactions with other basic research funding agencies
• Assure that science in each portfolio is of high quality
  – SAB review, AFOSR Spring review, external reviewers
  – AFOSR Director discussions with leaders in the field
• Collect evidence of 6.1 funded activities transitions
  – Other agencies fund activities initiated by AFOSR

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<thead>
<tr>
<th>Number of Follow-on Uses</th>
<th>907 Follow-on-Uses Reported</th>
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<tr>
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<td>(FY2011, 60% Response Rate)</td>
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- Assist
- Transfer
- Transition

AFOSR Sponsored 70 Nobel Laureates

2010 Nobel Prize in Physics - Andre Geim & Konstantin Novoselov
University of Manchester

1997 Nobel Prize in Physics - Steven Chu
Dept of Energy
Summary

AFOSR continues to *discover, shape, and champion* basic science *that profoundly impacts the future Air Force*

- Supporting world-class basic research
- Educating tomorrow’s scientific leaders
- Providing meaningful transitions and for future
- Enhance mutual understanding of AFOSR and other organizations missions, roles, programs, priorities
- Ensure current investments are fully coordinated and opportunities for leveraging are exploited

“Innovation also demands basic research. Today, the discoveries taking place in our federally-financed labs and universities could lead to ... New lightweight vests for cops and soldiers that can stop any bullet. Don't gut these investments in our budget. Support the same kind of research and innovation that led to the computer chip and the Internet.”
- President Obama, State of Union Speech, 24 January 2012
Happy 60th Birthday

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1951 - 2011
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www.twitter.com/afosr

www.youtube.com/TheAFOSR
Questions