



Air Force Research Laboratory



AFOSR Overview

5 March 2012

Dr. Van Blackwood
Air Force Office of Scientific Research
Air Force Research Laboratory

Integrity ★ Service ★ Excellence





Happy 60th Birthday

AFOSR

1951 - 2011

AFOSR Spring Review March 5-9, 2012

Arlington VA

Viewing:

<http://www.ustream.tv/channel/spring-review-2012>

<http://onlinemediaevent.com/afosrspringreview/>

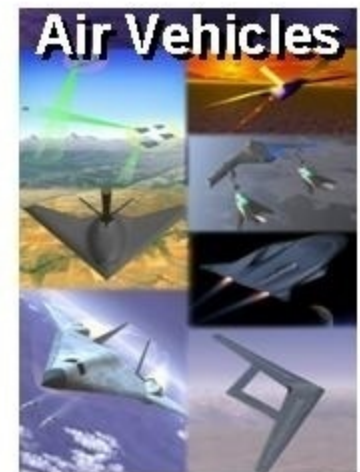
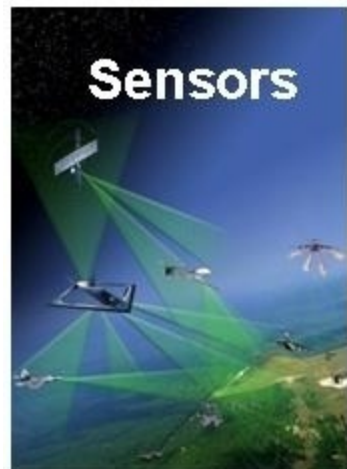
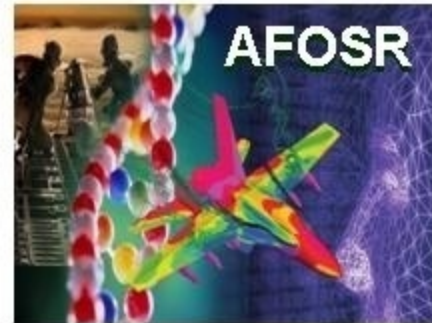
Archive:

https://community.apan.org/afosr/spring_review_2012/





AFRL Technical Directorates

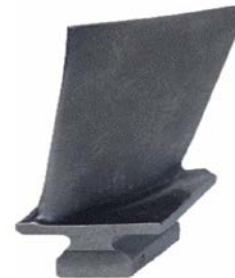




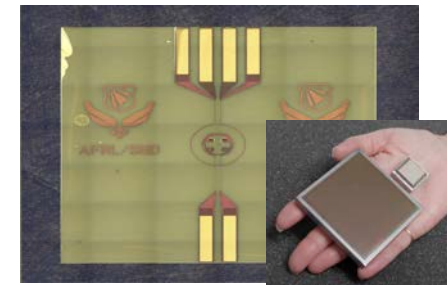
AFOSR Supports AFRL Core Technical Competencies (CTC)



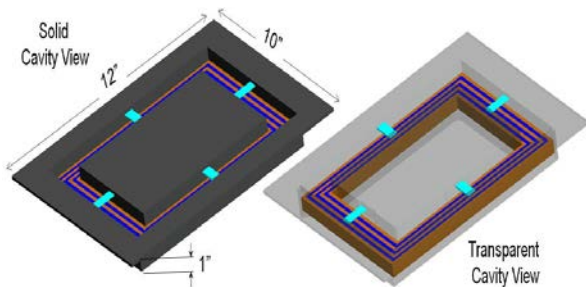
RH – Discover & quantify size, shape, motion & molecular signatures indicative of threat



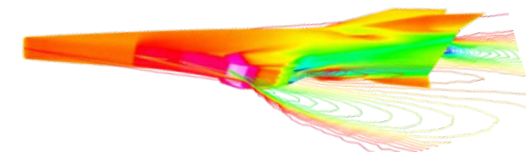
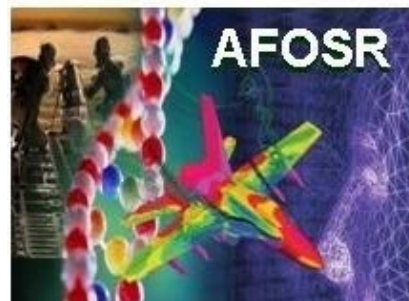
RX - Develop new alloy and tailor micro-structure for turbine blade



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



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



RB – Research in high speed-hypersonic flight



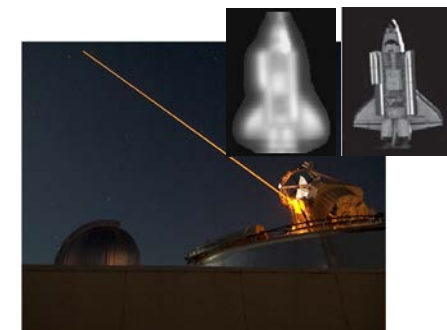
RI – Develop robust cyber command and control system



RZ – Development of scramjet propulsion



RW - Developing new fuse and sensors technologies



RD - Higher-quality image restorations. Enhanced using adaptive-optics research





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

TODAY'S BREAKTHROUGH SCIENCE FOR TOMORROW'S AIR FORCE



AFOSR Roles



AF Basic Research Manager

- **Identify Breakthrough Research Opportunities – Here & Abroad**
 - Regular interactions with leading scientists and engineers
 - 64 workshops conducted; 195 conferences co-sponsored
 - Int'l liaison offices in Europe, Asia, Latin America
 - 227 short-term foreign visitors; 22 personnel exchanges
- **Foster Revolutionary Basic Research for Air Force Needs**
 - 1327 extramural research grants at 228 U.S. universities
 - 590 fellowships; 2224 grad students, 344 post-docs on grants
 - 268 intramural research projects at AFRL, USAFA, AFIT
 - 96 summer faculty; 50 postdocs/senior scientists at AFRL
- **Transition Technologies to DOD and Industry**
 - 153 STTR small business - university contracts
 - 700 funded transitions (follow-on-uses) from FY10 PI data call



Shaping the Research Portfolio



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!*



Shaping the Research Portfolio



Though a principal source of new scientific opportunities is bottom up from the scientific community through AFOSR PMs, we also consider the assessment of opportunities by AF and OSD

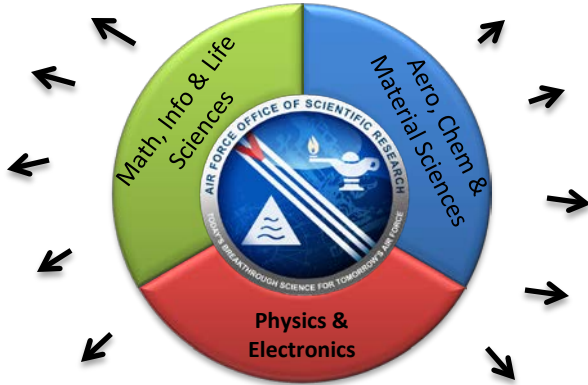
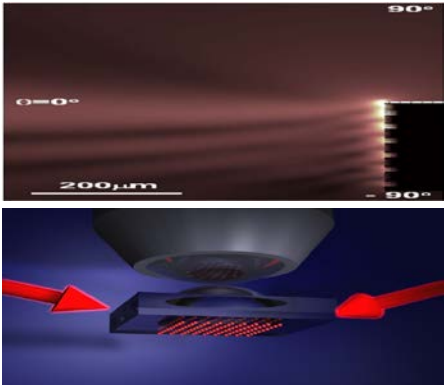
AF/ST "Technology Horizons"

Inherently Intrusion-Resistant Cyber Networks

Trusted Highly-Autonomous Decision-Making Systems

Hyper-Precision Air Delivery in Difficult Environments

Fractionated, Composable, Survivable Remote-Piloted Systems



Metamaterials and Plasmonics

Quantum Information Science

Cognitive Neuroscience

Nanoscience and Nanoengineering

Synthetic Biology

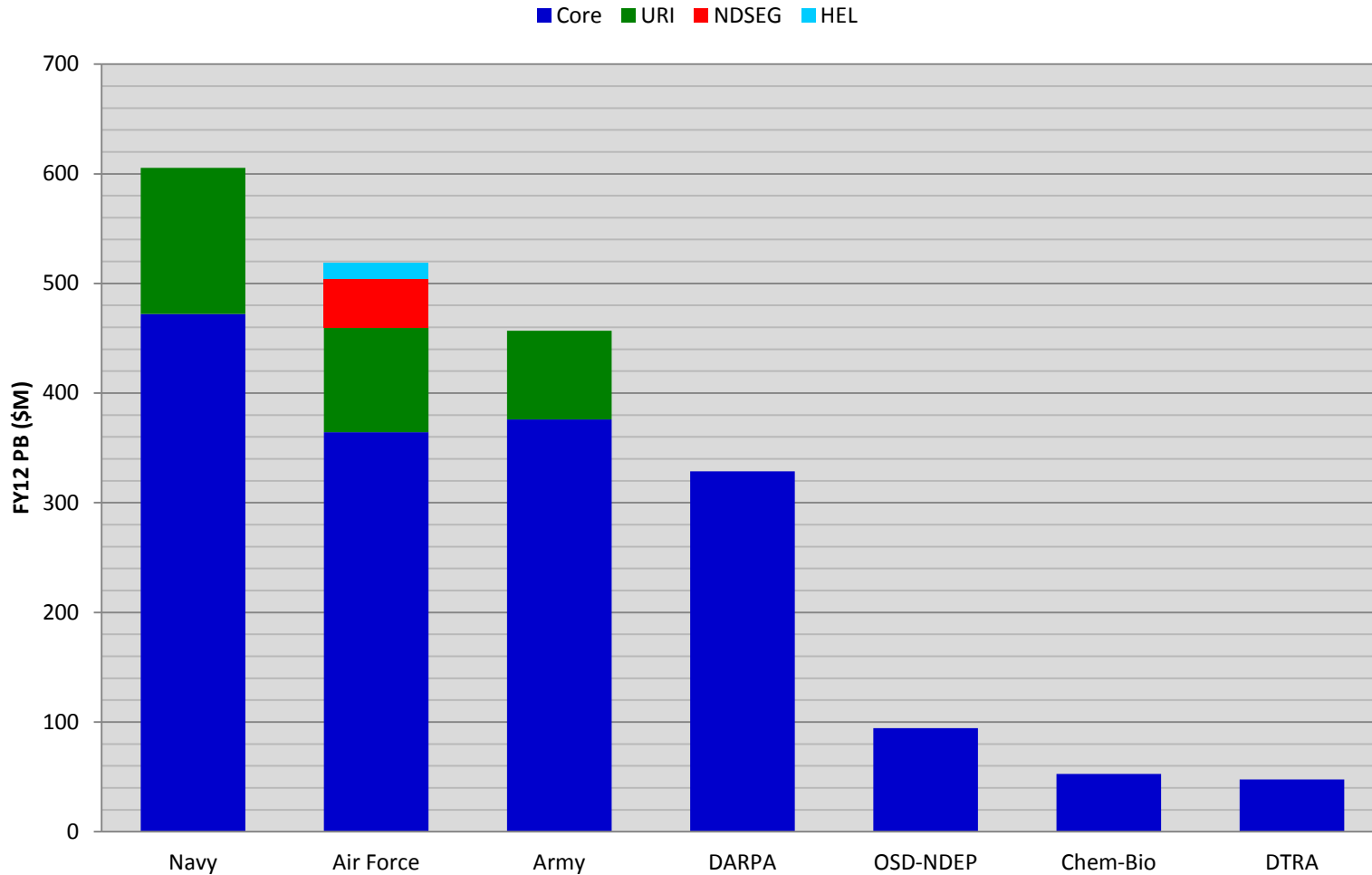
Computational Models of Human Behavior

ASD(R&E) "Six Disruptive Basic Research Areas"





DoD Basic Research Enterprise



DoD Total FY12 Basic Research Budget = \$2.12B

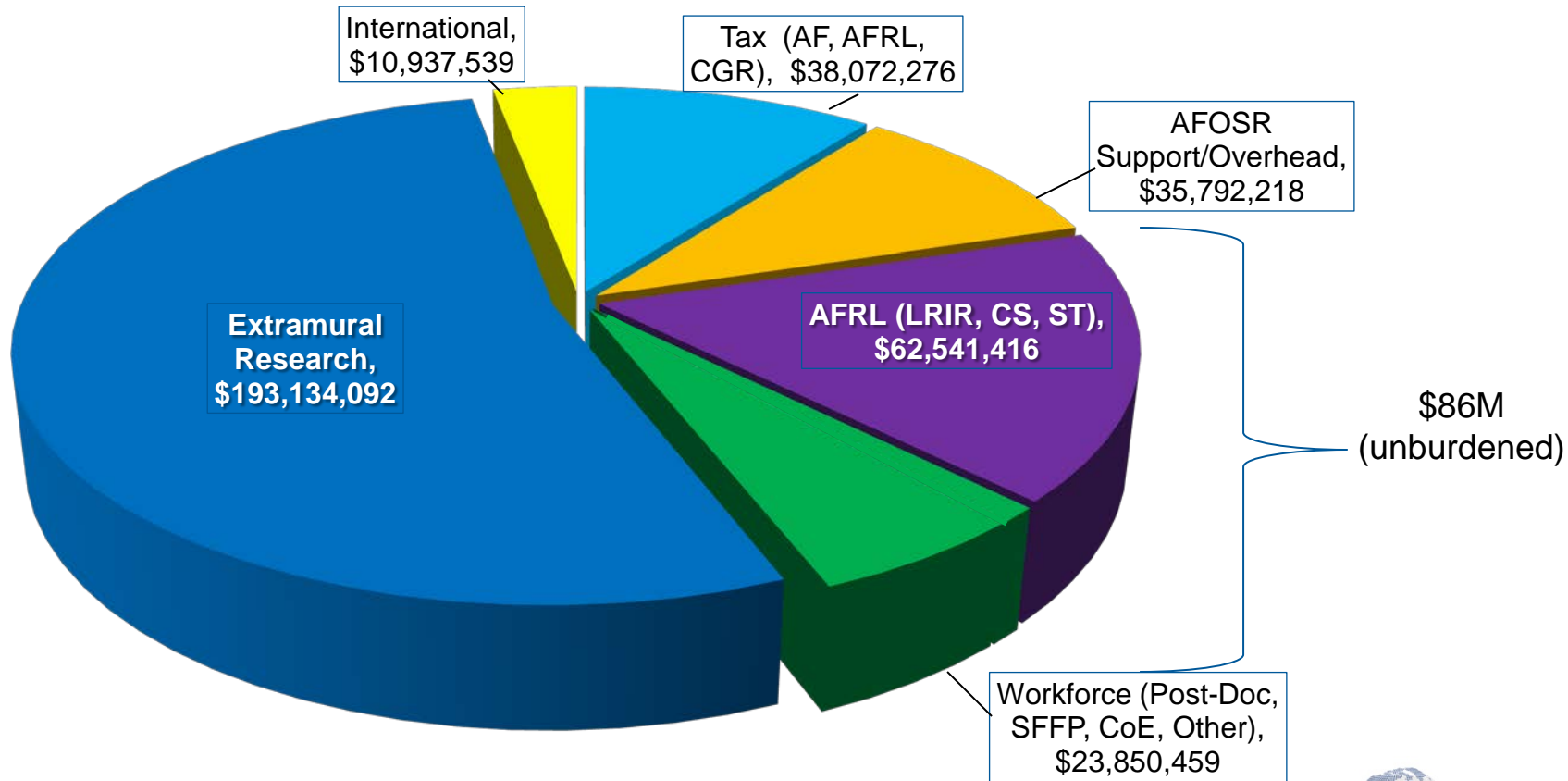




AFOSR FY12 Budget Plan



Program Element	FY 2011	FY 2012	FY 2013*	FY 2014*
61102F (Core)	348,910	364,328	361,787	374,267
61103F (URI)	135,601	140,273	141,153	138,747





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 Submission 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>**

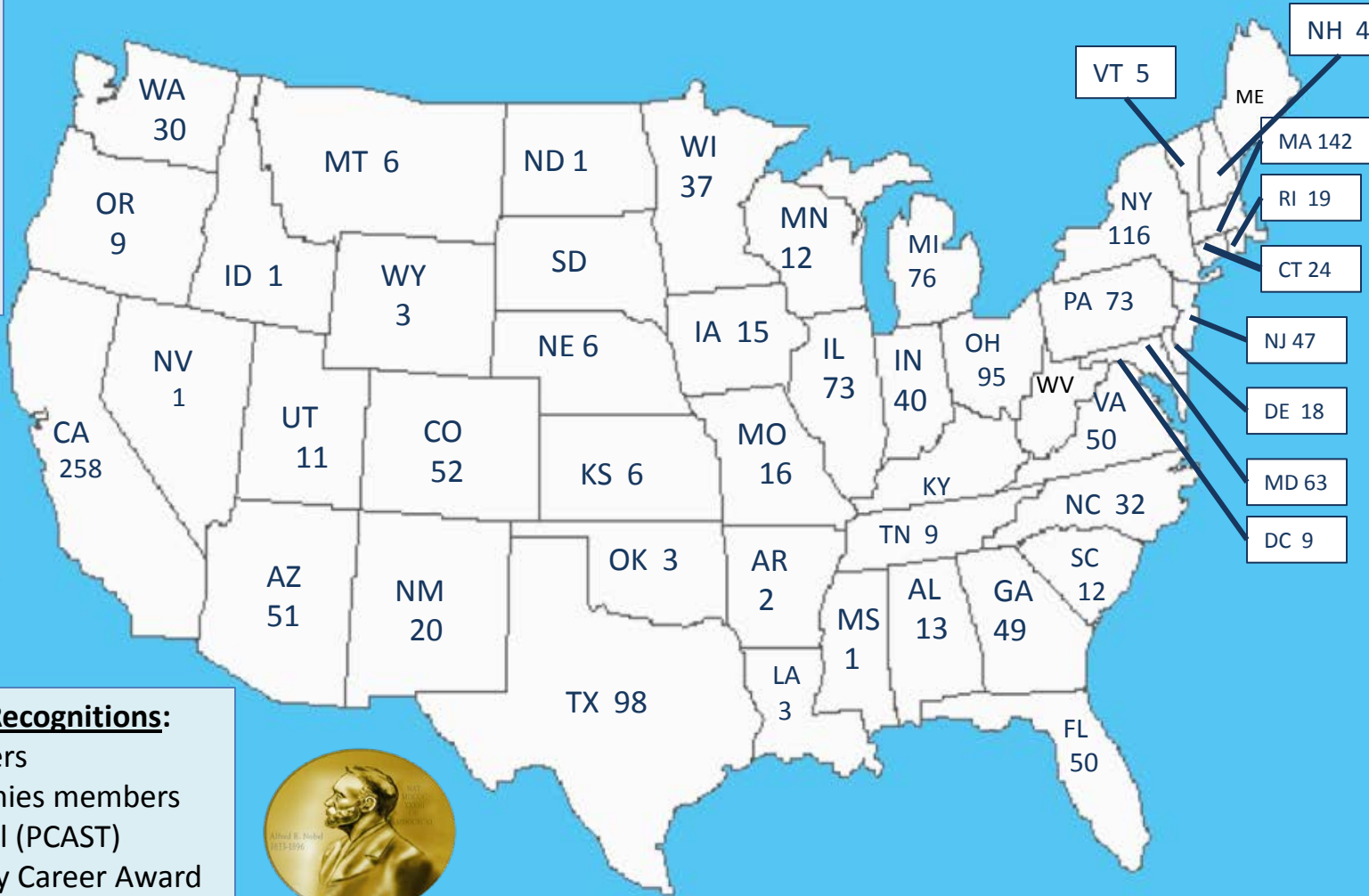


FY11 Research Projects Performed Throughout U.S.



Top Funded Univ.

- Stanford
- Georgia Tech
- MIT
- Univ. of Michigan
- Univ. of Maryland
- Princeton
- Berkeley
- Ohio State Univ.
- UC-San Diego
- Univ. of Illinois



Current PI Awards & Recognitions:

- 4 - Nobel Prize winners
- 52 - National Academies members
- 2- President's Council (PCAST)
- 20 - Presidential Early Career Award
- 115 - Professional Society Fellows
- 131 - Young Investigator Program

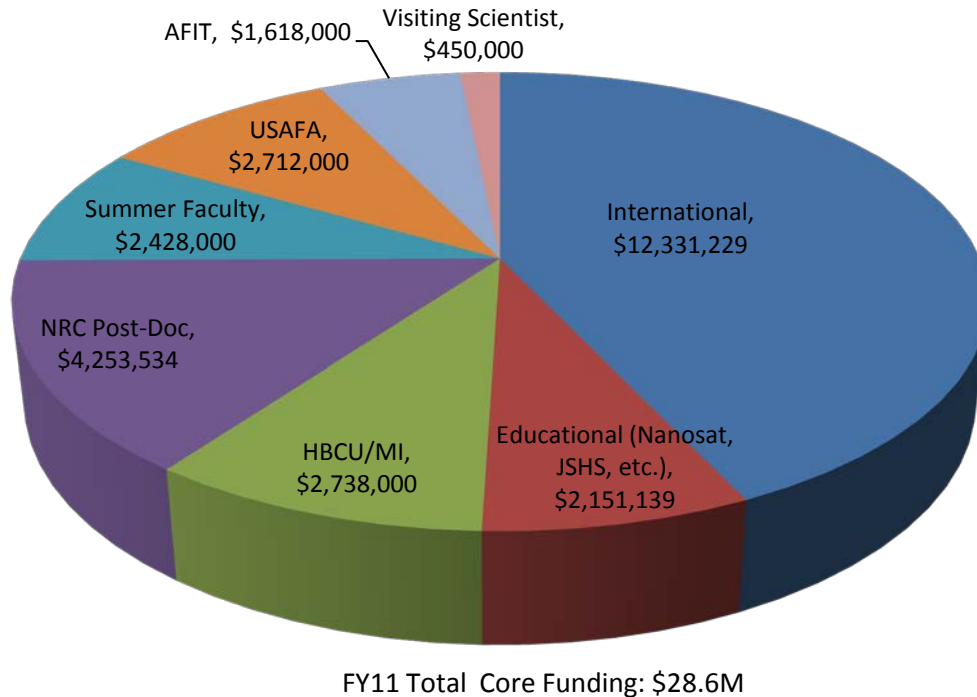


AFOSR Sponsored 70 Nobel Laureates

Total # of Projects (Core & URI): 1672



Education and Outreach



ASSURE site at Fort Johnson, NY



USA Science & Engineering Festival, DC 2010

Educational Projects in 61103F (URI)

- **National Defense Science and Engineering Graduate Fellowship (NDSEG) Program (\$36M):** Supporting 590 PhD-track graduate students in DoD relevant fields
- **Awards to Stimulate and Support Undergraduate Research Experience (ASSURE) (\$4.5M):** Provides 550 undergraduates with research opportunities in S&E fields of DoD interest during summer months

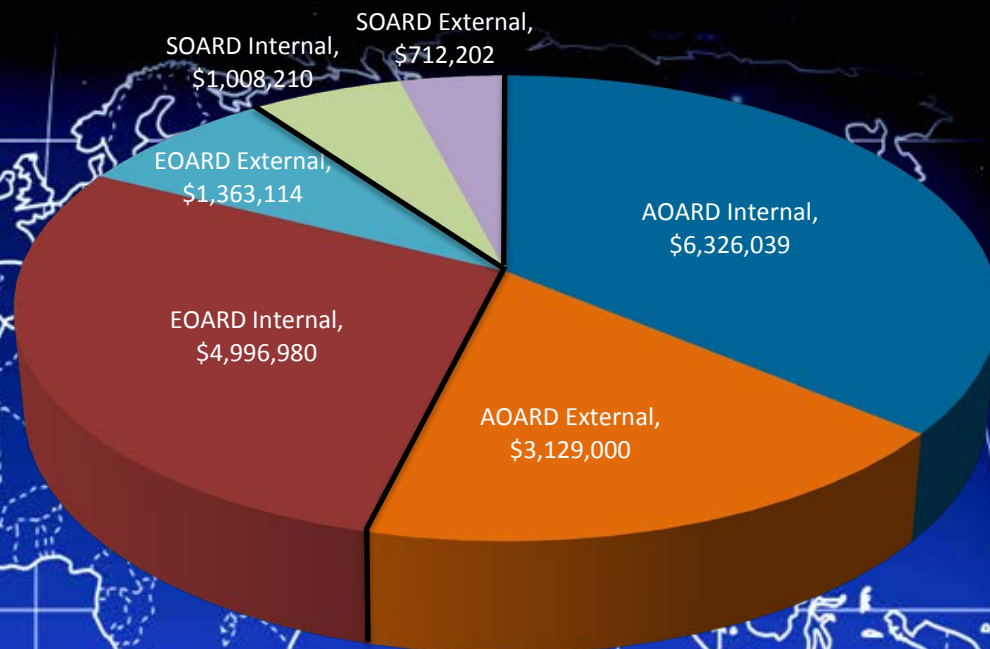


AFOSR International Enterprise



Total Funding (All Sources): \$17.5M

- **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

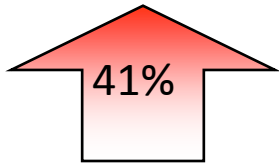
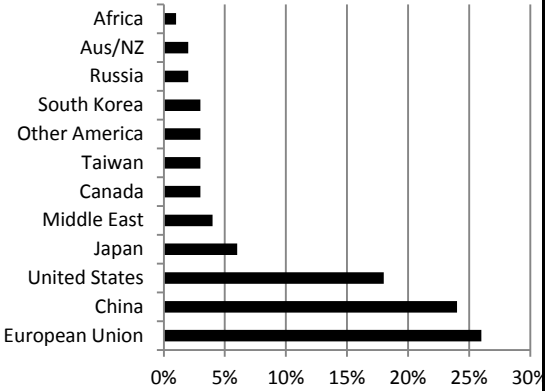
The Sun Never Sets on AFOSR



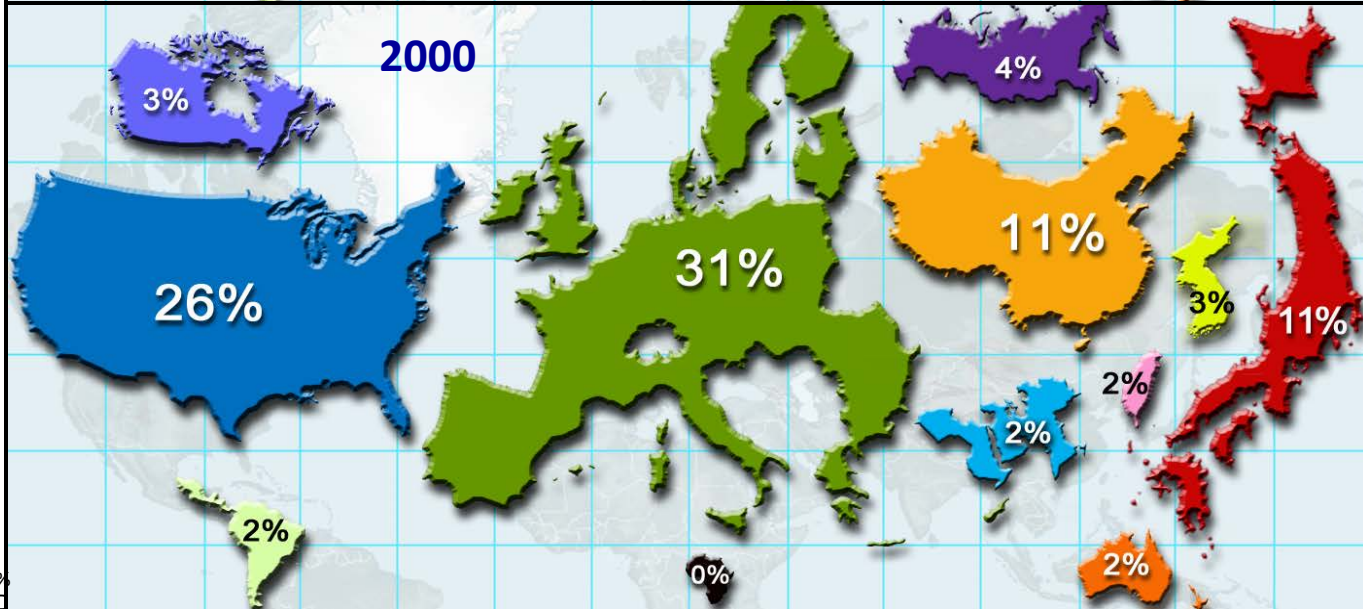
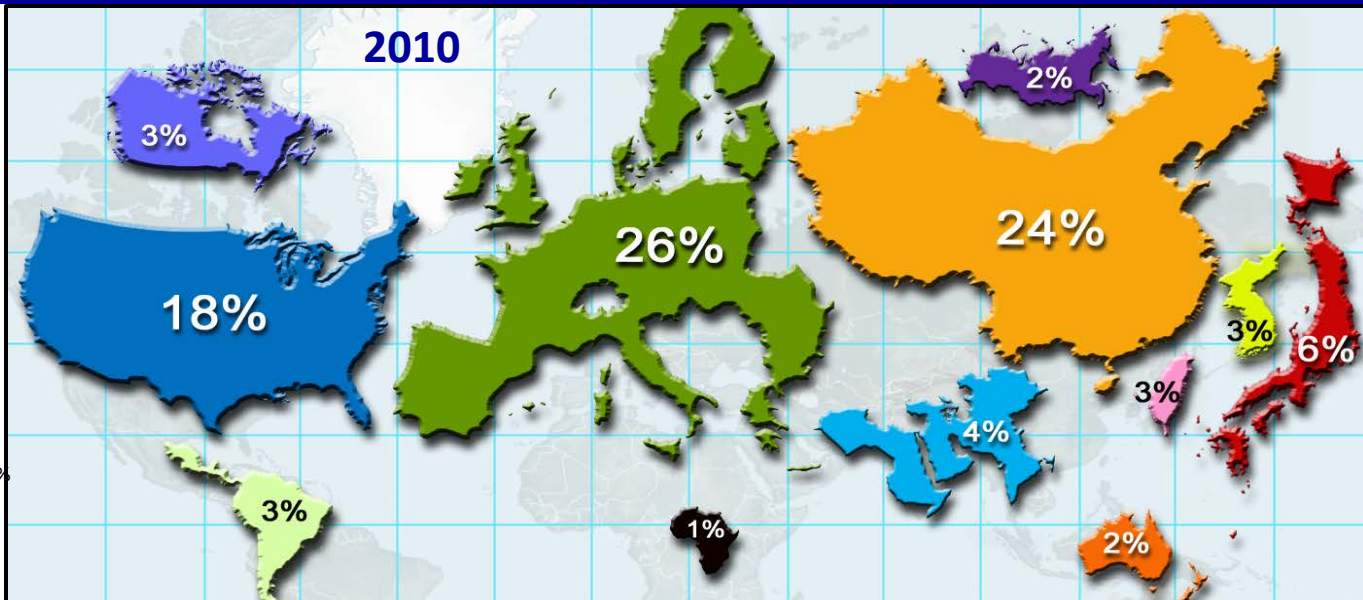
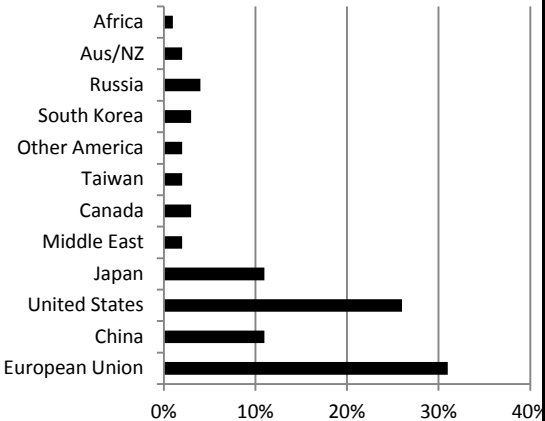
World R&D Publications (2000 to 2010): US share of global R&D steadily decreasing



2010 898,416 Articles



2000 636,358 Articles



AFOSR Ten Focus Areas

(FY12 - \$364.3M)

Aerospace, Chemical & Material Sciences

- Aero-Structure Interactions & Control
- Energy, Power & Propulsion
- Complex Materials & Structures

Physics & Electronics

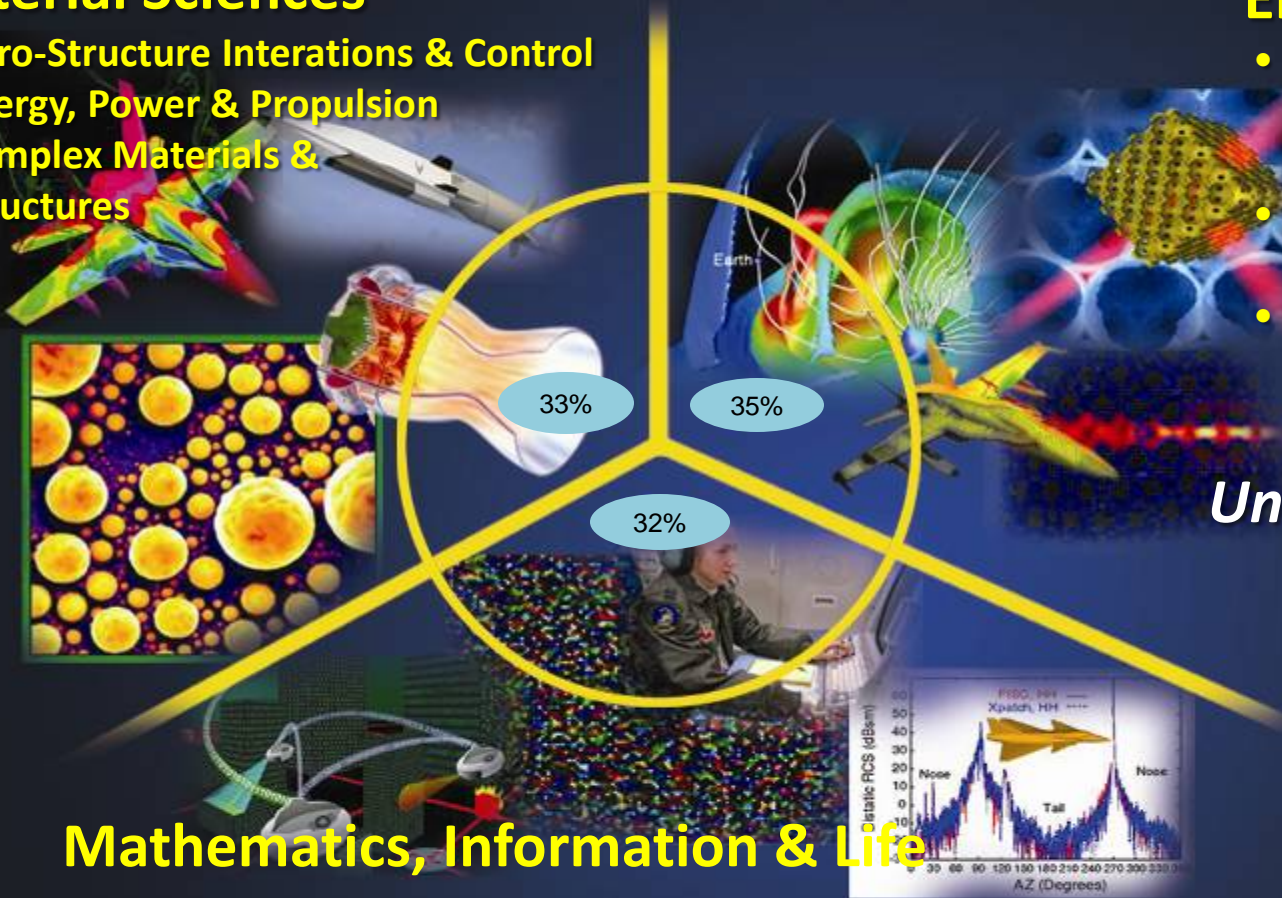
- Complex Electronics & Fundamental Quantum Processes
- Plasma Physics & High Energy Density
- Optics, EM, Comm, Signals Processing

University Research Initiatives

(FY11 - \$140.2M)

Mathematics, Information & Life Sciences

- Info & Complex Networks
- Decision Making
- Dynamical Sys, Optimization & Control
- Natural Materials & Systems





Mathematics, Information & Life Sciences



Industry, \$5.8

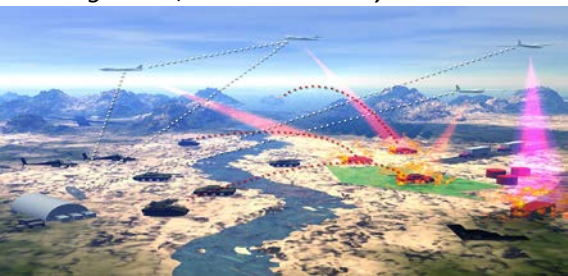
AFRL,
\$14.9

Academia, \$128.1

Performers (Total \$148.8M)



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.

Information and Complex Networks:

- Science of cyber security
- Mathematics of complex networks
- Software/algorithms for advance 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:

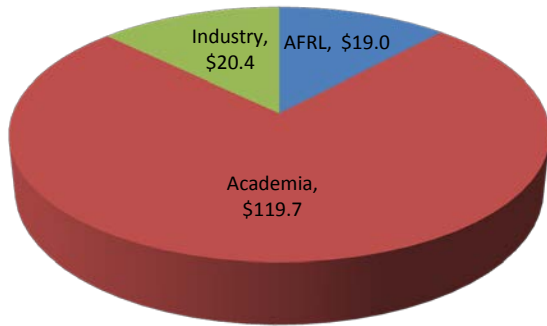
- Multiagent, networked control
- Uncertain, information-rich, dynamic environments
- Contested environments
- Dynamic, data-driven control

Natural Materials and Systems:

- Bio-inspired materials
- Bio-derived materials including energy
- Bio-sensing
- Extremophiles



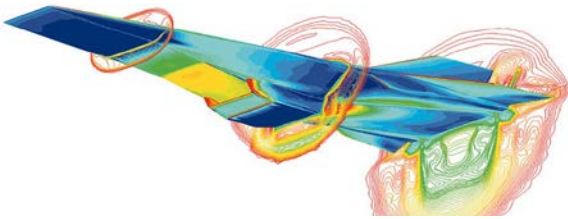
Aerospace, Chemical, and Material Sciences



Performers (Total \$159.1M)

Aero-Structure Interactions and Control:

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



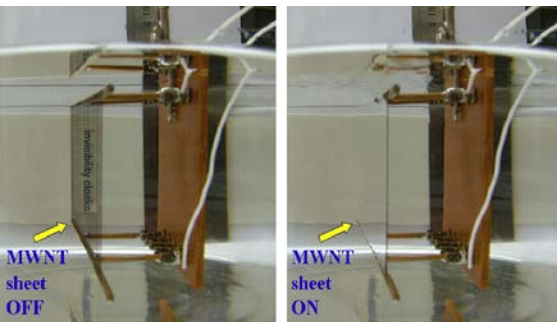
Energy, Power and Propulsion:

- 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

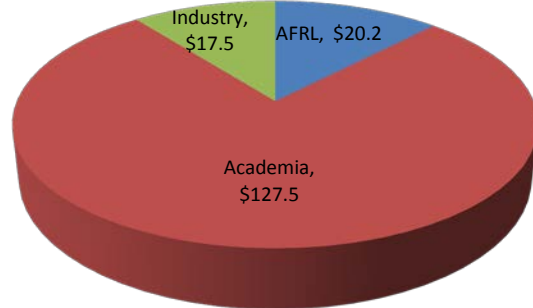
Model-free simulations of >Mach 3 shock turbulent boundary layer interactions



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



Physics & Electronics



Performers (Total \$165.2M)

Complex Electronics and Fundamental Quantum Processes:

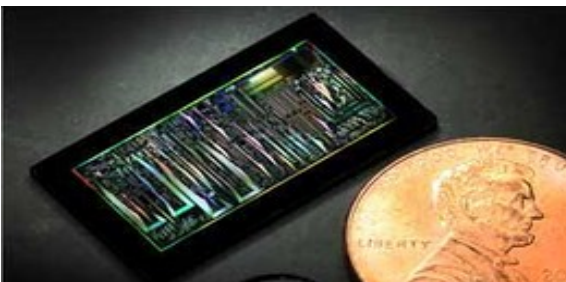
- Ultracold Atoms & Molecules
- Metamaterials & Graphene
- Dielectric and Magnetic Materials
- High Temperature Superconductors
- Novel Sensing Devices and Architectures
- Non-linear Optical Materials, Optoelectronics, and Nanophotonics



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

Plasmas & High Energy Density Nonequilibrium Processes:

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



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

Optics, Electromagnetics, Communication, & Signal Processing:

- Information fusion
- Lasers and non-linear optics
- RF and EO signal processing
- Novel RF devices and communication architectures



Basic Research Initiative Program



- The Basic Research Initiative program provides a mechanism to fund new Projects aligned to identified emphasis areas.
- Funded by a 10% assessment on the prior year budgets of all research portfolios (PE61102F funding)
- Program managers nominate research topics that are reviewed for scientific merit and alignment to the AFOSR technical strategy
- New research areas identified via a broad agency announcement

FY12 BRI Topics

- 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
- Reliance optimization for autonomous systems
- Bio-nanocombinatorics
- Design under uncertainty of complex engineering systems



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



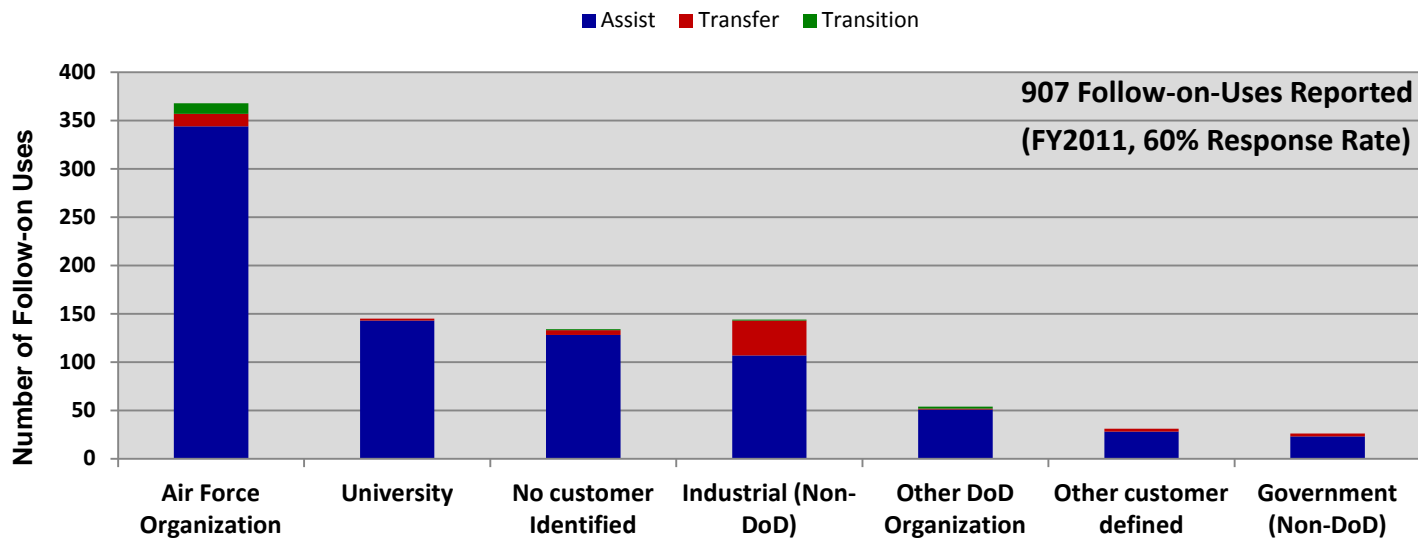
AFOSR Sponsored 70 Nobel Laureates



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

Social Media



AIR FORCE OFFICE OF SCIENTIFIC RESEARCH 1951 - 2011 AFRL

www.facebook.com/afosr



www.twitter.com/afosr



www.youtube.com/TheAFOSR





BACK-UP for SAB



Trends in AFOSR Emphasis



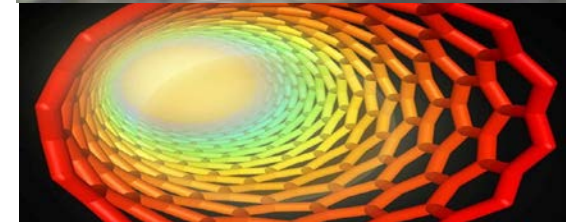
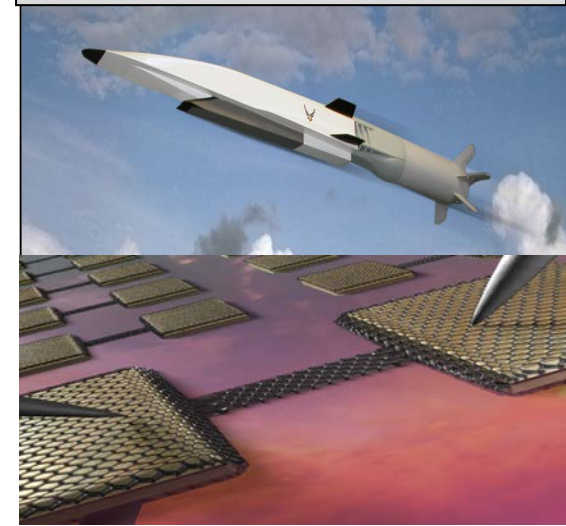
- Advanced Mathematics
- Hypersonics (Turbulence Control)
- Complex, Multi-Functional Materials
- High-Temperature Superconductivity
- Info Assurance and Network Sciences
- Micro Air Vehicles (Autonomy, Adaptive Aero)
- Interfacial Sciences (Thermal, Tribology)
- Counter-Directed Energy Weapons
- Robust Decision-Making, Info Fusion
- Socio-Cultural Modeling, Minerva
- Quantum Information Sciences
- Space Situational Awareness
- fs-Laser Material Interactions
- Artificial Intelligence

RED = PBD709 (OSD Interest)

BLUE = AF Tech Horizons

Grand Challenges

GREEN = Both





Invest in AF “Technology Horizons” Research Areas



- **PBD 709 Topic Enhancements**

- Information Assurance
- Interacting Complex Networks
- Artificial Intelligence
- Socio-Cultural Modeling

- **Materials and Processes Far from Equilibrium**

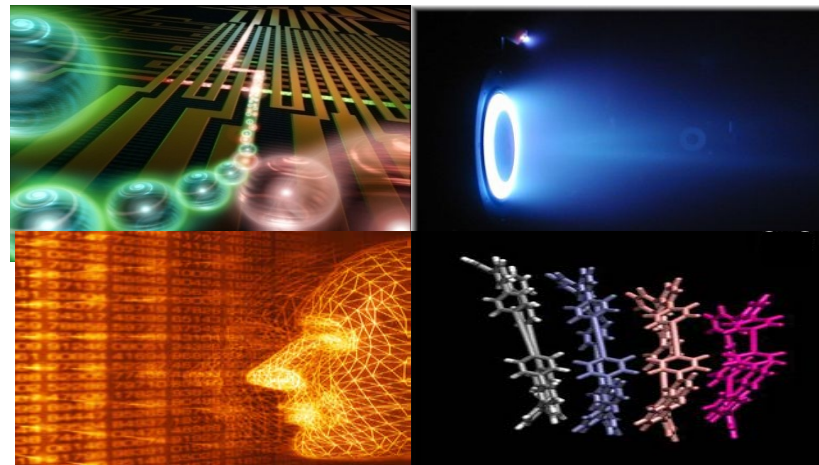
- Physics and Chemistry of Surfaces in Highly Stressed Environments
- Small Molecule Activation
- Extreme Optics

- **Transformational Computing**

- Neural Computing
- Bio-Inspired Distributed Control Sys.
- Beyond Moore’s Law Electronics
- Multiscale Modeling

Tech Horizons Grand Challenges

1. Inherently Intrusion-Resistant Cyber Networks
2. Trusted Highly-Autonomous Decision-Making Systems
3. Fractionated, Composable, Survivable Remote-Piloted Systems
4. Hyper-Precision Air Delivery in Difficult Environments





International Research Achievements



- **Perching of Micro Air Vehicles: R. Radespiel, Technische Universität Braunschweig, (EOARD)**

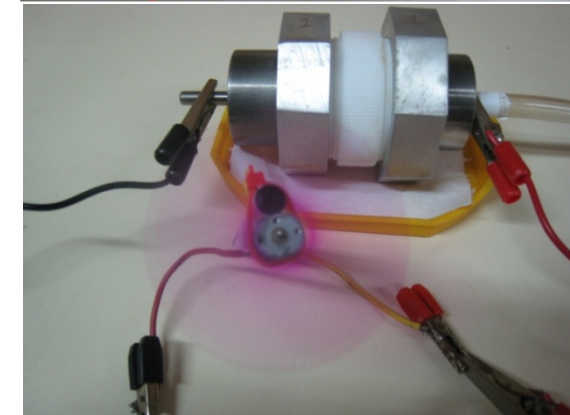
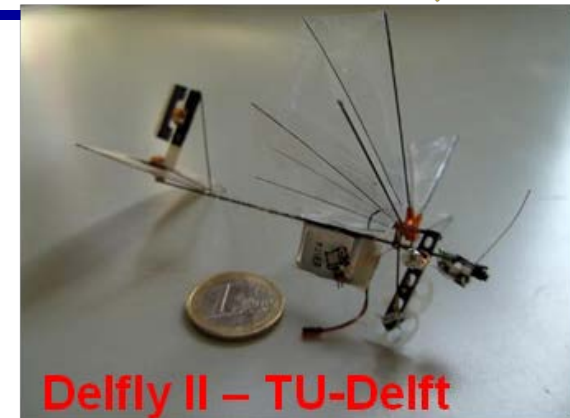
Identified & characterized unsteady flow phenomena on flat plate wings during perching motion by force measurement and particle image velocimetry.

- **Lithium - Air Battery: M. Nookala, Indian Institute of Science, India, (AOARD)**

Li-air batteries use a catalytic air cathode that supplies oxygen, an electrolyte and a lithium anode. Potential to have a capacity for energy storage that is 5 to 10 times greater than that of Li-ion batteries.

- **Photorefractive Polymers: Research Center in Advanced Chemistry (CIQA), Mexico, (SOARD)**

Developed the world's smallest ferroelectric nanoparticles – small as 9 nm. High resolution proved hypothesis that surface stress was key to success.

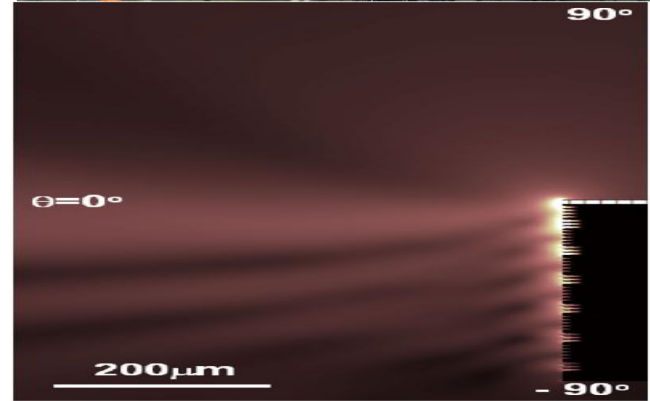
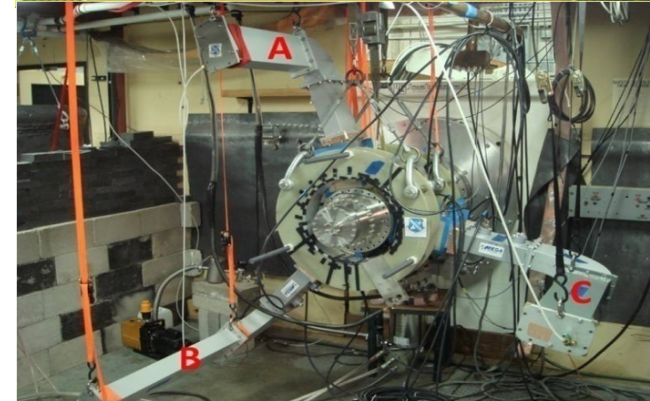
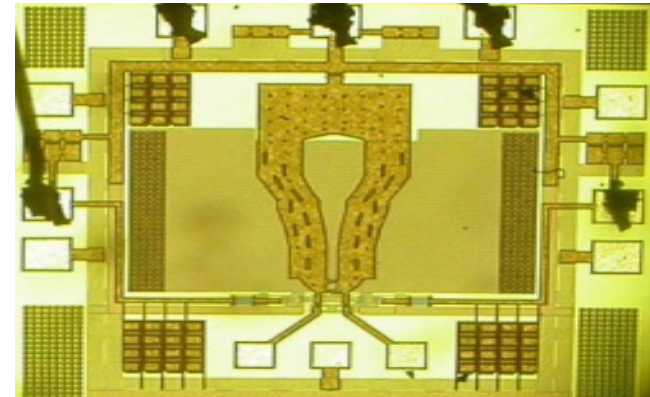




Physics & Electronics



- **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.



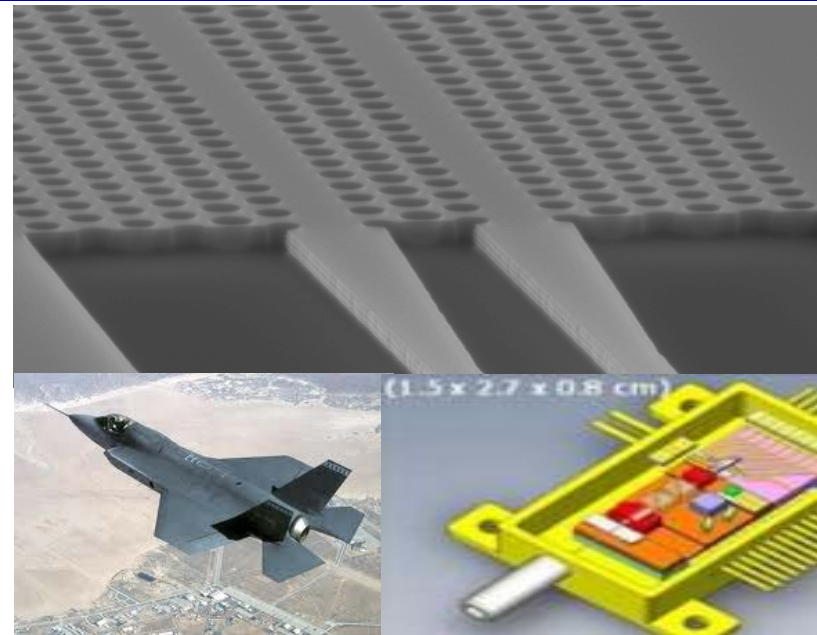


Chip-Scale Silicon Photonic Device



- Warfighter Capability

- Developed a novel designs for all optical analog-to-digital converters simulated and realized in photonic crystal platforms. New designs achieved beyond terabits per second data rate transmission to support advanced electronic warfare, radar and communications systems.



Network enabled wavelength division multiplexed highly integrated photonic routing fabric for JSF-F35. It has ability to dynamically reconfigure the logical connections of the fiber optic network.

- Enabling S&T

- AFOSR had first national level program focused on nano-photonics, have been leading in funding chip scale plasmonics, photonic crystals, nano-antennas, nano-emitters & modulators.

Transition Path





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 biodegradable. 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.





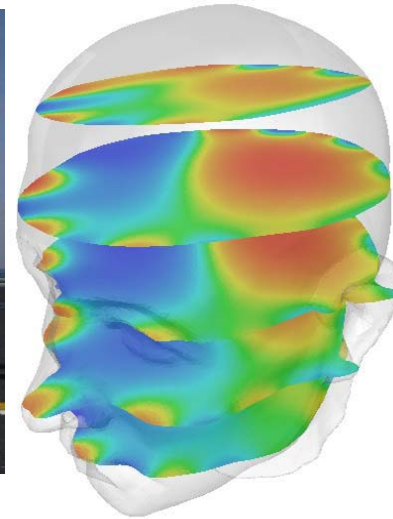
Noise Attenuation

Achieved 50 dB Attenuation Goal of DTO HS-33



• Warfighter Capability

- Protect flight line operators and warfighters from noise induced hearing loss, fatigue and decrease errors associated with fatigue due to noise and vibrations.

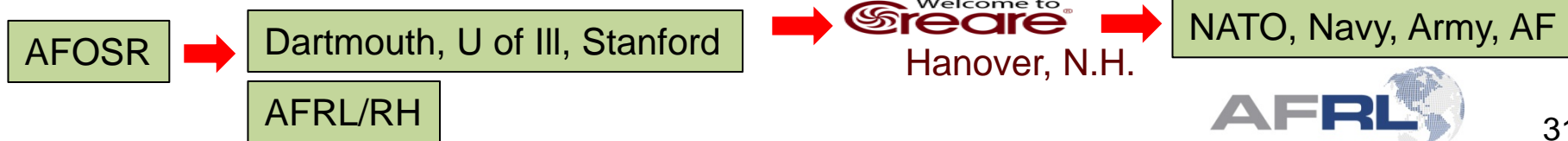


• Enabling S&T

- Developed head and neck simulator that enabled attenuation of noise levels without exposure to human subjects. Coordinated STTR, 6.1, 6.2 efforts

- Developed a physiologically realistic, instrumented human head simulator
- Measured and model dynamics of middle ear transduction
- Developed new techniques for noise cancellation (active and passive)
- Instrumented Head Simulator enabled acoustic tests without risk to human listeners

Transition Path

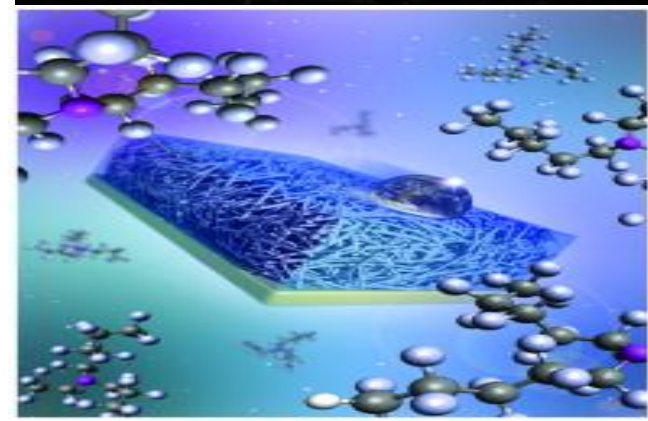
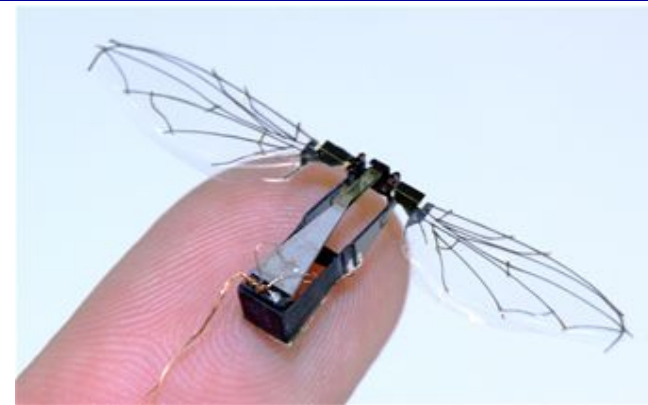




Aerospace, Chemical, and Material Sciences



- **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 CO₂ 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.





Thermally Remendable Composites

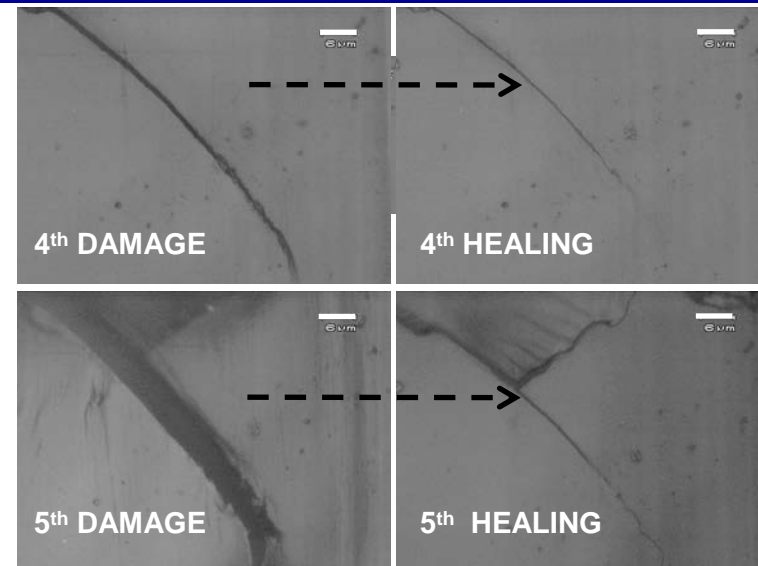


• Warfighter Capability

- Developed a novel technique that can automatically detect and repair structural cracks in composite air platforms and structures.

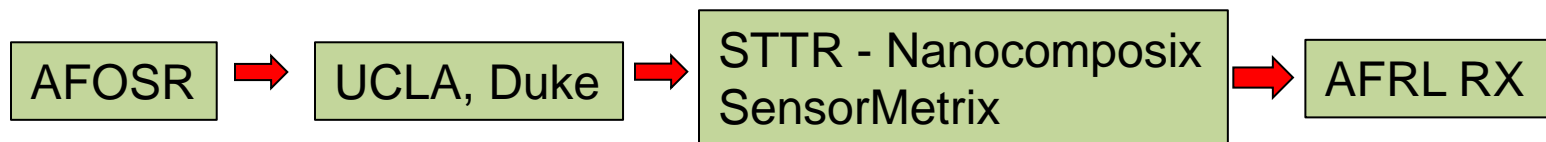
• Enabling S&T

- Bio-inspired technology that automatically detects damage to structures and initiates “healing” of the damaged area. This method does not require any human intervention.



Technology to alleviate structural problems with aircraft decreasing maintenance and aircraft downtime.

Transition Path



Bio-inspired research may lead to *self sensing and healing capability*

