AFOSR: Basic Research- Game Changing Investments

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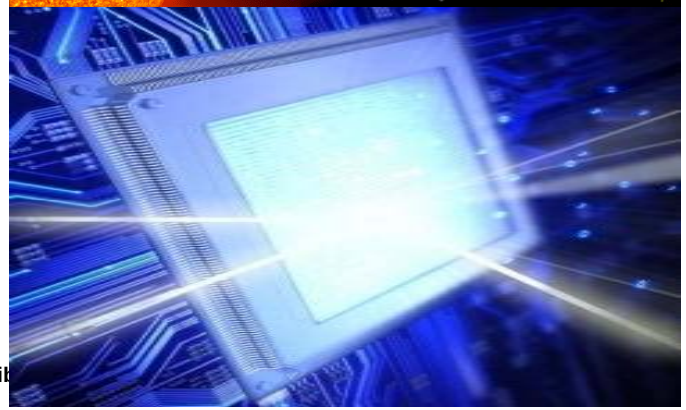
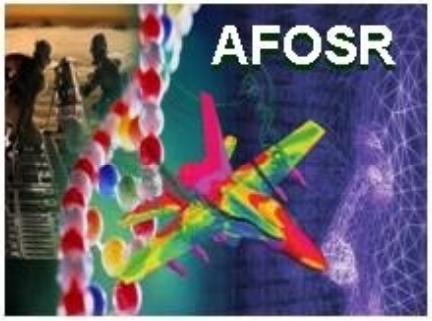
Integrity ★ Service ★ Excellence

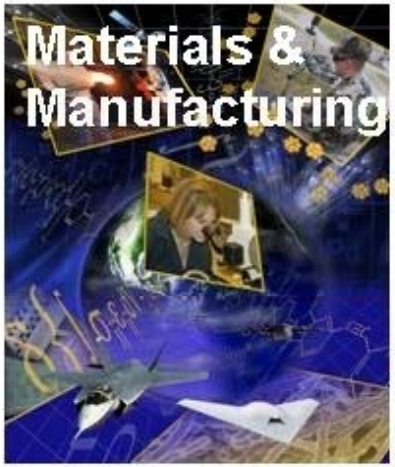
Contents

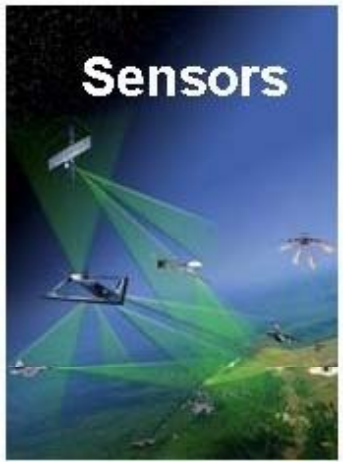
- **AFOSR Overview**
- Research Focus Areas; Transitions
- AFOSR International Program

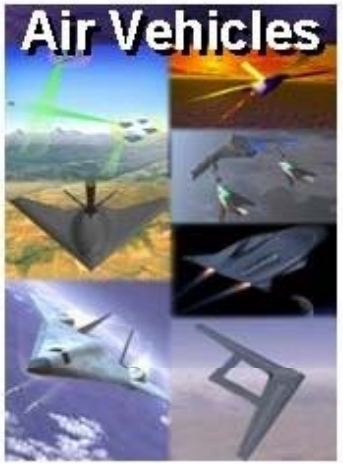


Air Force Research Laboratory









The Air Force's Corporate Research and Development Laboratory

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

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**

Multidisciplinary University Research Initiative (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 8-10 research topics per Service
  - Occasional joint topics
  - One or two awards per topic
- Currently there are 61 AFOSR MURI Projects (FY05-09)
  - 10 new projects in FY10

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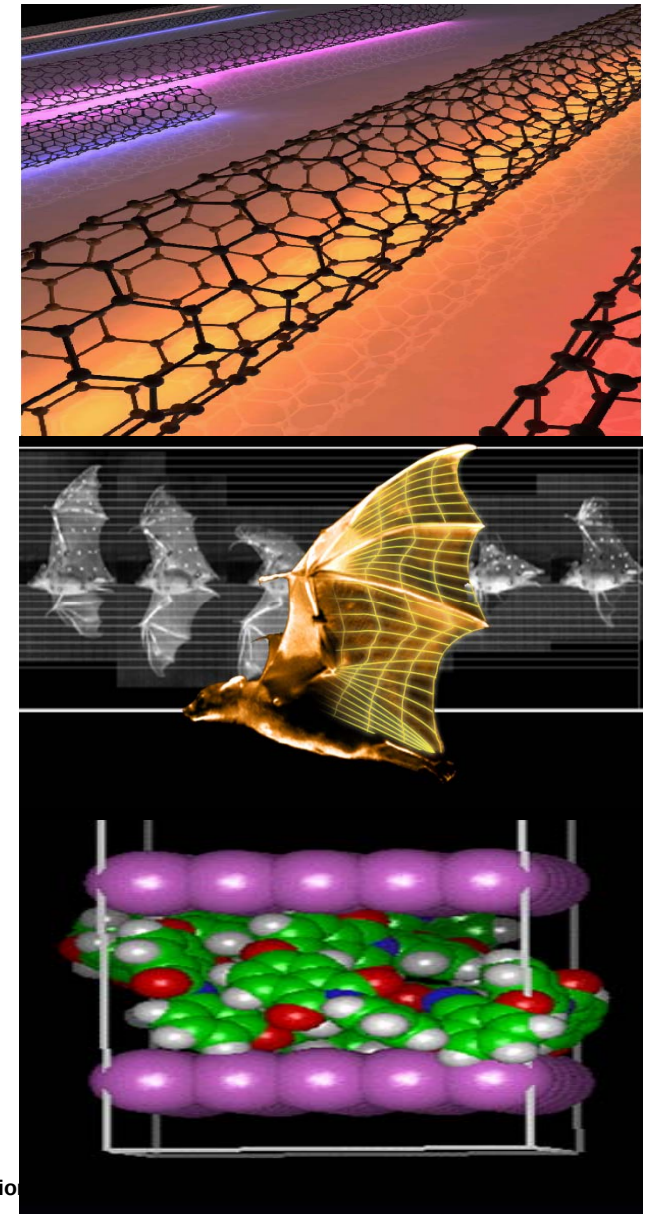
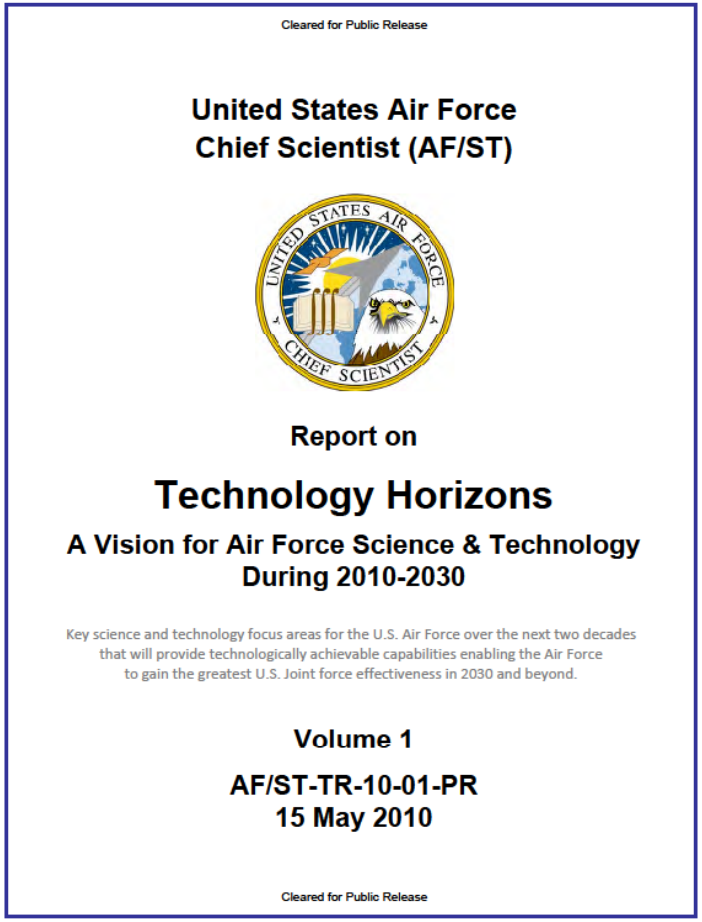


AF/ST Technology Horizons

- Focus on 10-20-year time horizon
- Tech Horizons Grand Challenges:
  - Inherently Intrusion-Resistant Cyber Networks
  - Trusted Highly-Autonomous Decision-Making Systems
  - Fractionated, Composable, Survivable Remote-Piloted Systems
  - Hyper-Precision Air Delivery in Difficult Environments
- Not all the technologies require new basic science



Cleared for Public Release

United States Air Force
Chief Scientist (AF/ST)

Report on

Technology Horizons

A Vision for Air Force Science & Technology
During 2010-2030

Key science and technology focus areas for the U.S. Air Force over the next two decades that will provide technologically achievable capabilities enabling the Air Force to gain the greatest U.S. Joint force effectiveness in 2030 and beyond.

Volume 1

AF/ST-TR-10-01-PR
15 May 2010

Cleared for Public Release

Available at: http://www.af.mil/information/technologyhorizons.asp

Basic Research (Focus Areas)

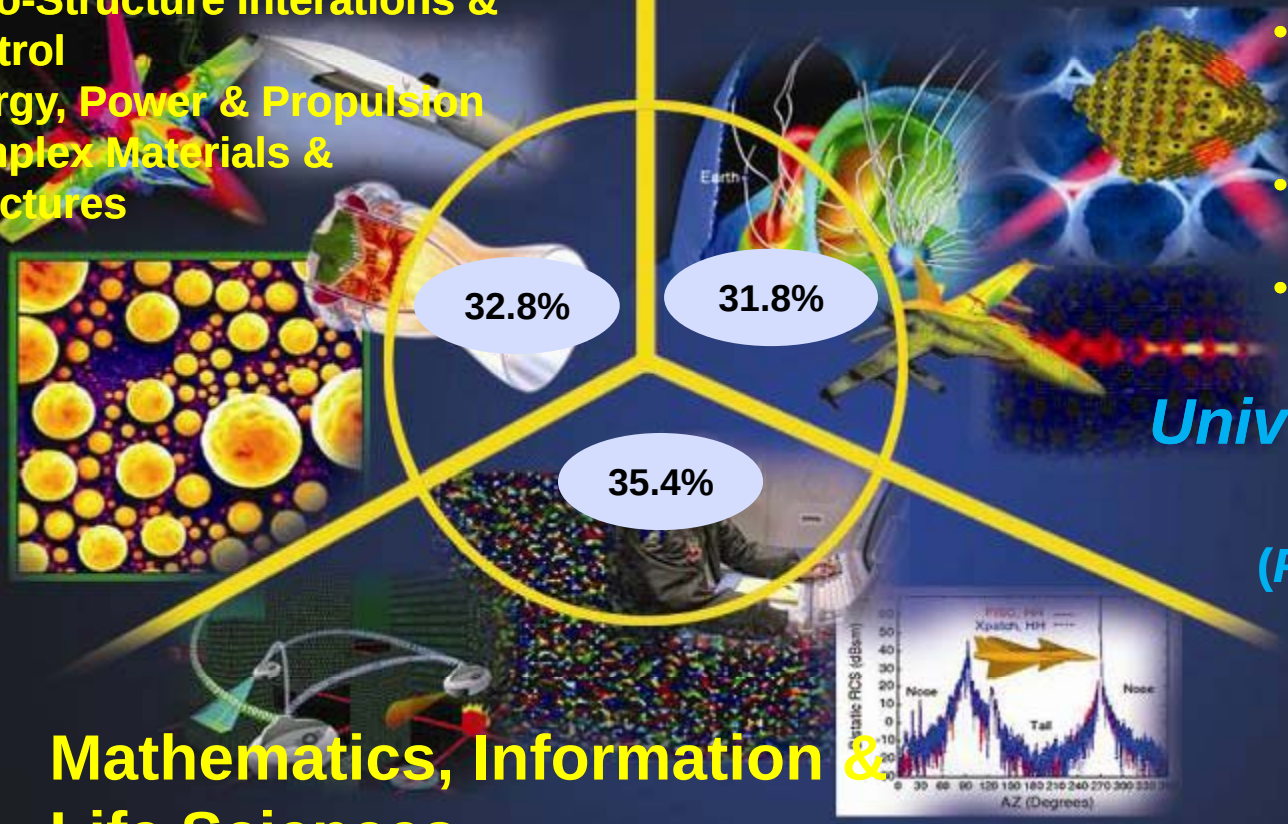
(*FY11PB* - $351M)

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



University Research Initiatives

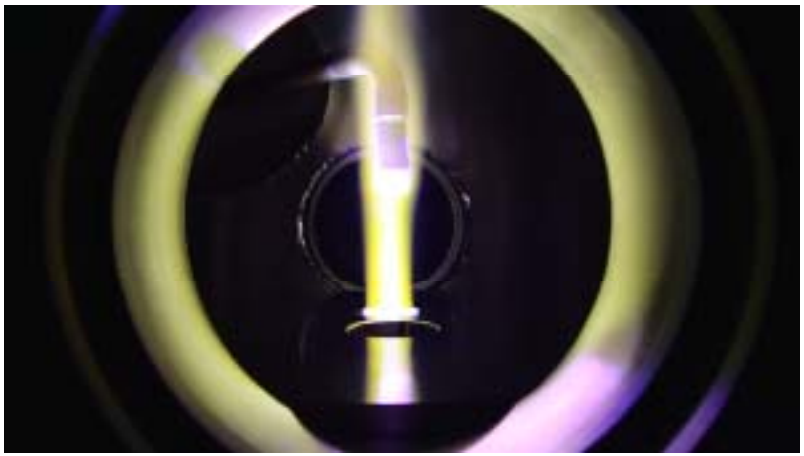
(*FY11PB* - $136M)

Mathematics, Information & Life Sciences

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

Aero-Structure Interactions and Control

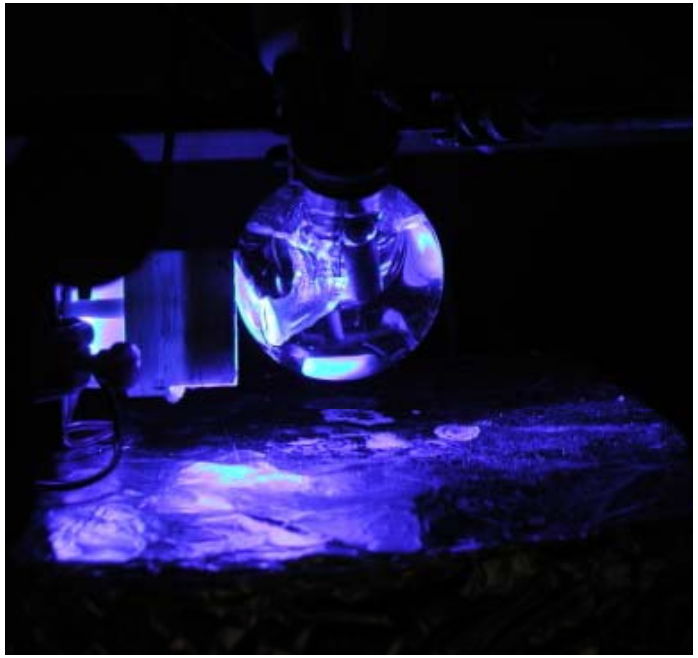
- Objective: Characterization, modeling, and exploitation of interactions between unsteady aerodynamic flow fields and dynamic air vehicle structures.
- Critical Subjects Include:
  - Turbulence and laminar-turbulent transition
  - Flow control
  - Unsteady aerodynamics
  - Structural dynamics
  - Aero elasticity



30 kW Inductively Coupled Plasma Facility for High Temperature Material Testing

Energy, Power, and Propulsion

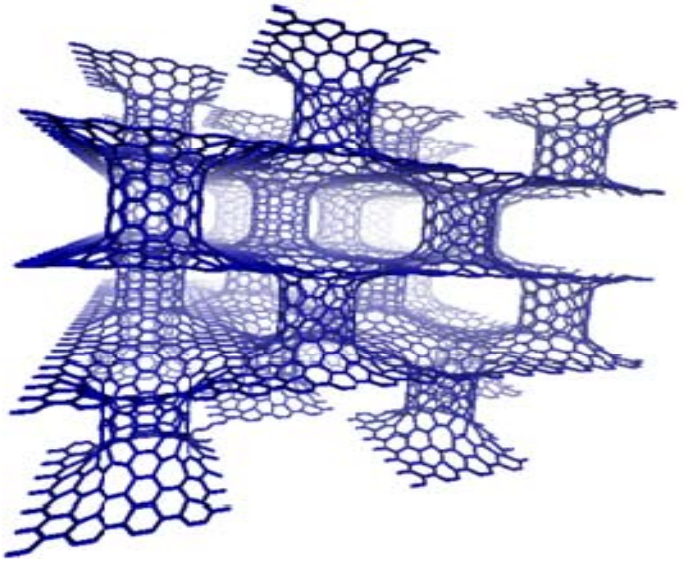
- Objective: Focus on the production, storage, and efficient utilization of energy.
- Critical Subjects Include:
  - Novel energetic materials
  - Combustion research
  - Thermal science
  - Novel propulsion methods
  - Catalysis chemistry
  - New ways in which energy can be produced/collected/stored/utilized



Blue light (465 nm) is used to convert CO_2 to alcohols with a substituted pyradine catalyst and a p-GaP electrode.

Complex Materials and Structures

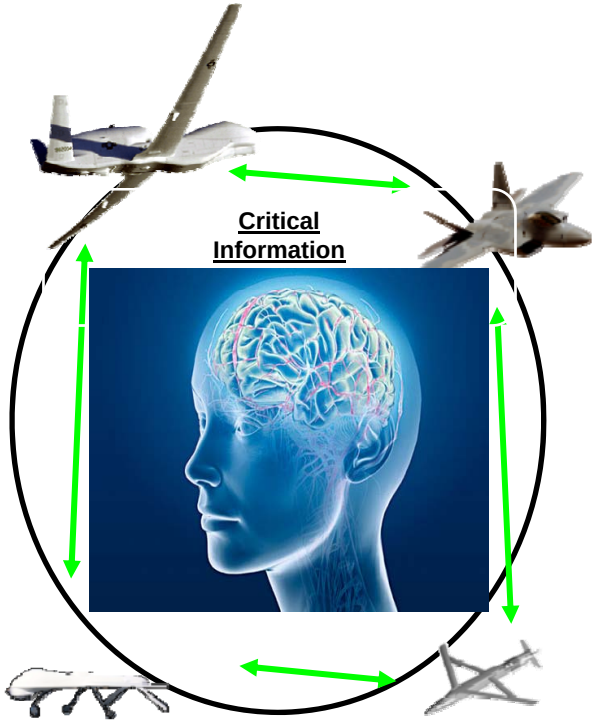
- Objective: Future materials and structures that incorporate hierarchical design and functionality from the nanoscale through the mesoscale to effect functionality and/or performance characteristics to enhance the mission versatility of future air and space systems.
- Critical Subjects Include:
  - Materials with tunable properties
  - Adaptive morphing structures
  - Active materials with on-demand shape and phase change
  - Reconfigurable structures



3D Pillared CNT/Graphene Nano Structure

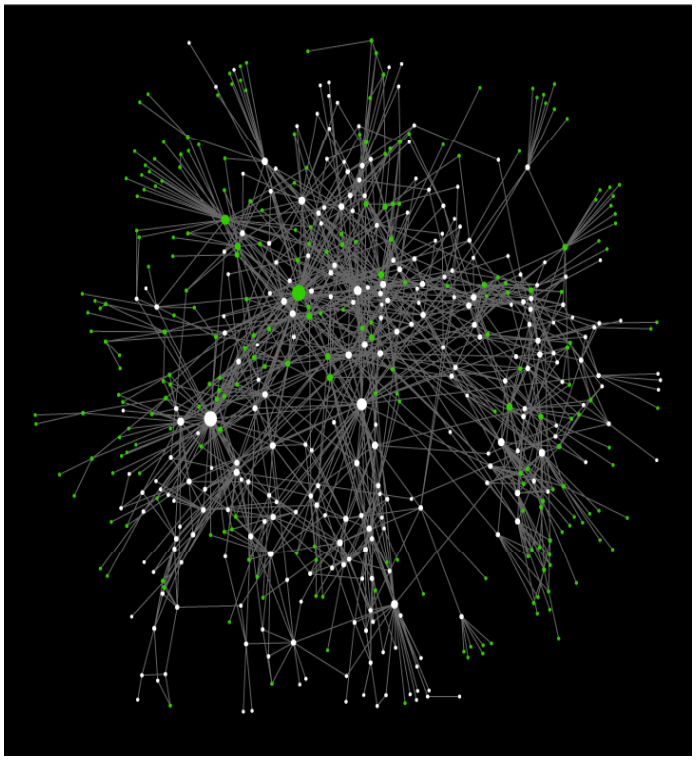
Decision Making

- Objective: Discovery of mathematical laws, foundational scientific principles, and new, reliable and robust algorithms, which underlie intelligent, mixed human-machine decision making.
- Critical Subjects Include:
  - Robust human-machine decision making
  - Socio-cultural modeling
  - Mathematical analysis and models of individual human cognition and collective behaviorCombining sensor, intelligence, and database information resources to formulate hypotheses about adversaries' intensions, information fusion



Information and Complex Networks

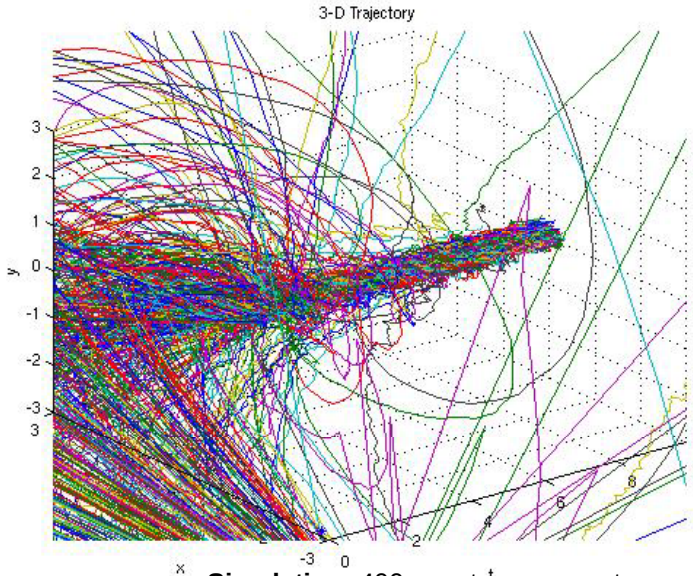
- Objective: Reliable and secure exchange of information and predictable operation of networks and systems.
  - Critical Subjects Include:
    - System and network performance prediction, design and analysis
    - Predict and manage network failure comprehensively
    - Information operations and security
    - Integration of models of computation and cognition for the specification and design of complex human-machine systems



Network Map

Dynamical Systems, Optimization, and Control

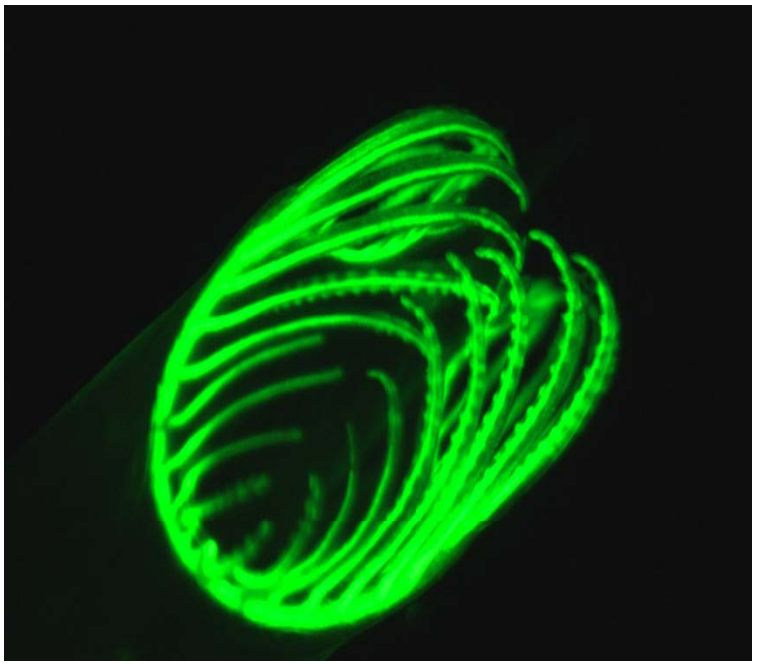
- To provide advances in in the science of autonomy including adaptive control for coordinating heterogeneous autonomous or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.
- Critical Subjects Include:
  - Embedded optimization
  - Dynamical systems theory
  - Reliable scalable algorithms
  - Computational and discrete mathematics
  - Management of the effects of uncertainties
  - Robust adaptive control of complex systems



Simulation: 400 agents converge to equilibrium under the Adaptive NCE Control Law

Natural Materials and Systems

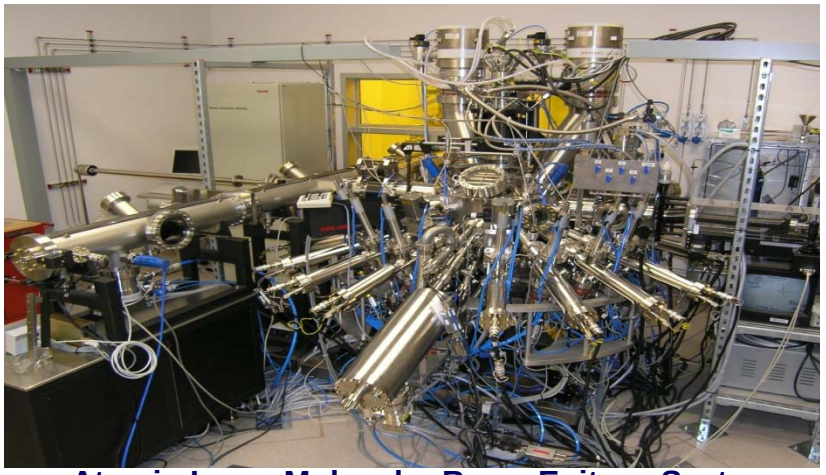
- Objective: Studying, using, mimicking, or altering the novel ways that natural systems build exquisite materials and sensors that often outperform manmade versions and perform under extreme conditions.
- Critical Subjects Include:
  - Biomimetics of materials and flight
  - Sensors
  - Interfaces
  - Extremophiles
  - Bioenergy



bfloGFP, a new family of fluorescent proteins from lancelet cephalochordate amphioxus

Complex Electronics and Fundamental Quantum Processes

- Objective: Pursue breakthroughs in information processing, secure communication, multi-modal sensing, computer memory, high speed communication and computing through exploration and understand of complex engineered materials and devices.
- Critical Subjects Include:
  - Non-linear Optical Materials
  - Optoelectronics and Nanophotonics
  - Ultracold Atoms & Molecules
  - Metamaterials & Graphene
  - Dielectric and Magnetic Materials
  - High Energy, Semiconductor and Ultrafast Lasers
  - High temperature Superconductors
  - Quantum Dots and Wells

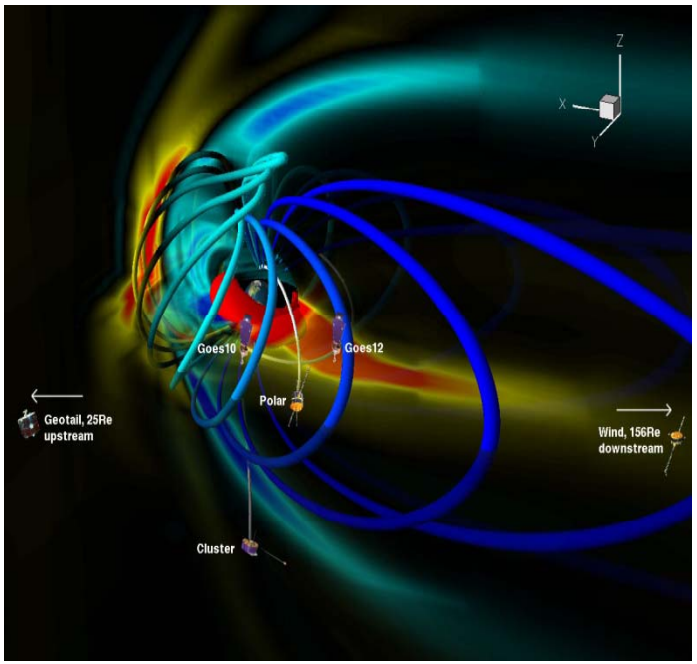


Atomic-Layer Molecular Beam Epitaxy System

Plasmas and High Energy Density Nonequilibrium Processes

- Objective: Pursue understanding of fundamental plasma, non-linear electromagnetic phenomena, and the non-linear response of materials to high electric and magnetic fields.

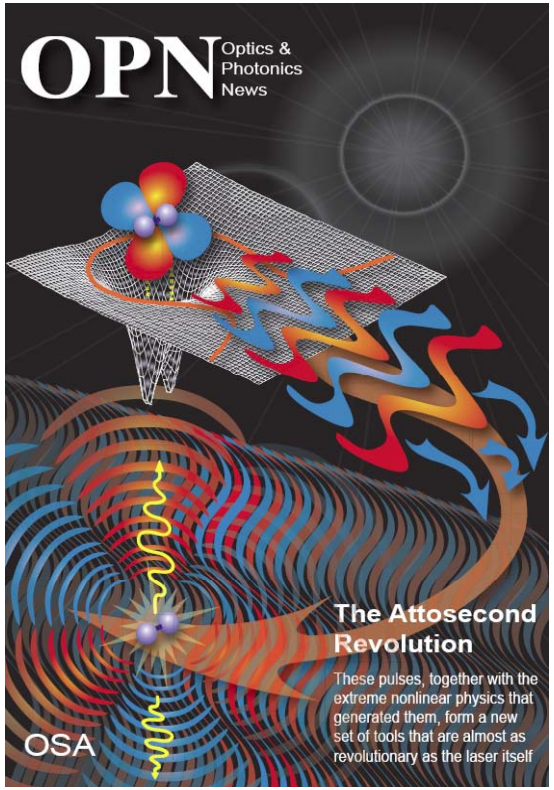
- Critical Subjects Include:
  - Space weather
  - Plasma discharges & non-equilibrium chemistry/thermo
  - Plasma control of boundary layers in turbulent flow
  - RF propagation and RF-plasma interaction
  - High power beam-driven microwave devices



The simulated heliosphere during the Halloween storms.

Optics, Electromagnetics, Communication, & Signal Processing

- Objective: Pursue understanding of complex electro-magnetic and electro-optical signals impacting space object imaging, secure reliable communication, on-demand sensing modalities, distributed multilayered sensing, automatic target recognition, and navigation.
- Critical Subjects Include:
  - Adaptive Optics and Optical Imaging
  - Laser Phenomenology
  - Precision Navigation and Timing
  - Sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals



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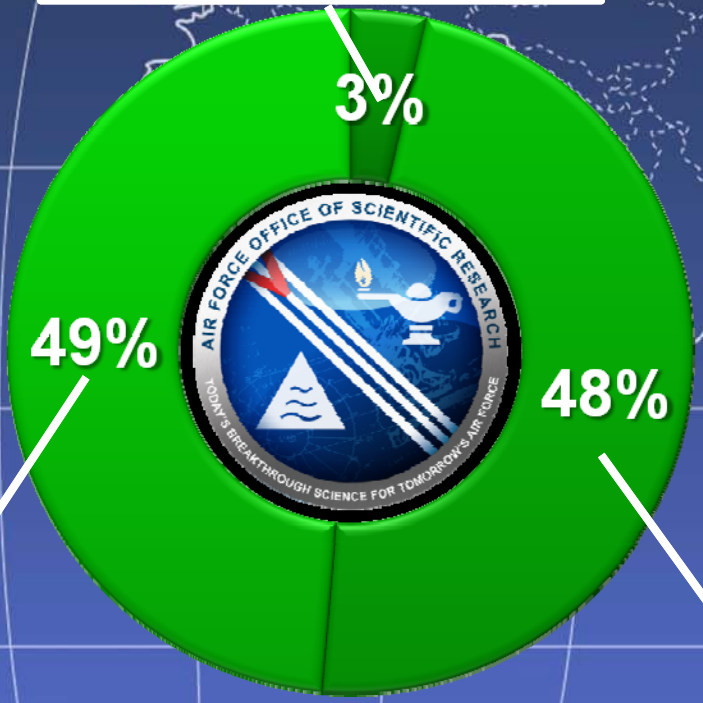
Hypersonic International Flight Research Experimentation (HIFiRE), is investigating the fundamental science of hypersonics technology and its potential for next generation aeronautical systems.

AFOSR International Enterprise

- *Building international goodwill*
- *Strengthening partnerships*

- *Avoiding technological surprise*

SOARD
SOUTHERN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT
Santiago



EOARD
EUROPEAN OFFICE OF AERSOPACE RESEARCH AND DEVELOPMENT
London

AOARD
ASIAN OFFICE OF AEROSPACE RESEARCH AND DEVELOPMENT
Tokyo

The Sun Never Sets on AFOSR

International Research Achievements

- **Agent-Based Computing in Distributed Adversarial Planning: Michal Pechoucek, Czech Tech Univ (EOARD)**

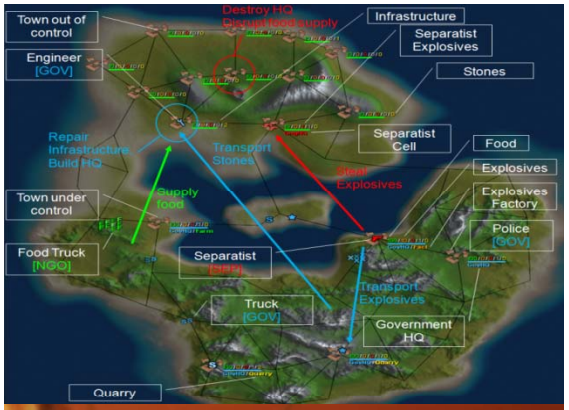
  A decision-making process through which an *agent* constructs a sequence of actions (possibly consisting of a single action only) leading to the desirable goal state of the world in an *adversarial situation.*

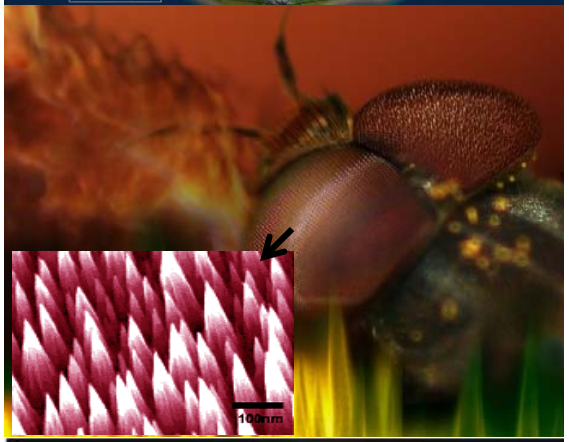
- **Biomimetic Silicon Nanostructure: Li-Chyong Chen, National Taiwan University, (AOARD)**

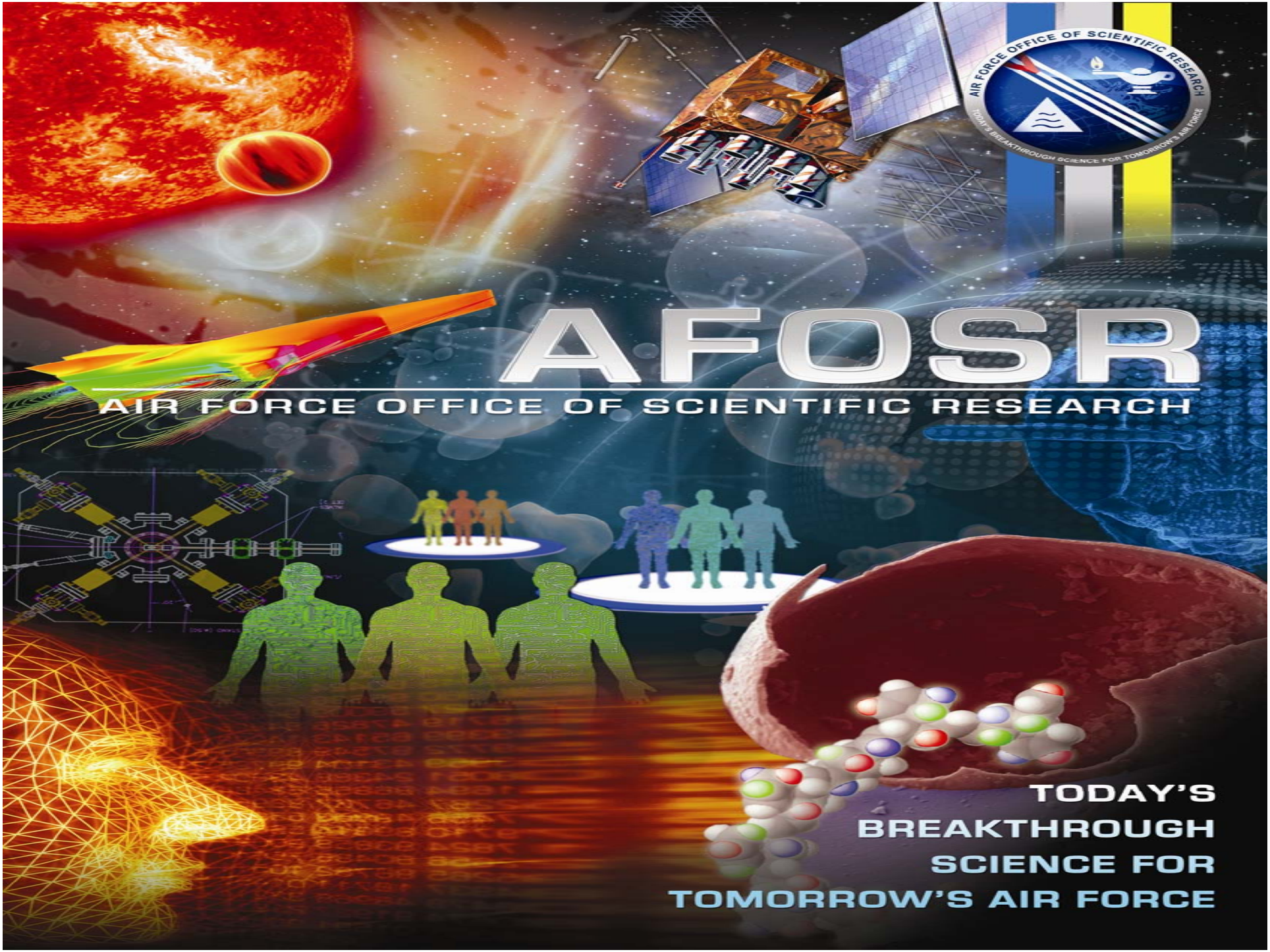
  Created nanostructure (nanotip) surfaces which mimic moth eye and surpass its function in anti-reflection in that they absorb almost all incident light.

- **Laser-Induced Air Breakdown in Hypersonic Flow: Sao Jose dos Campos, Brazil (SOARD)**

  Experimental study of hypersonic flow. Gearing up collaboration with Australian hypersonic project HIFIRE .



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