

# Air Force Office of Scientific Research Overview



**USAF/Taiwan Nanoscience Initiative  
Workshop – Honolulu, HI**

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# **AFOSR Mission**

**AFOSR Orchestrates the Air Force  
Basic Research Program with  
Universities, Industry, Other  
Government Organizations,  
and the AFRL Technical  
Directorates (TDs)**

**Creating Revolutionary Scientific Breakthroughs for the Air Force**



# Major AFOSR Activities

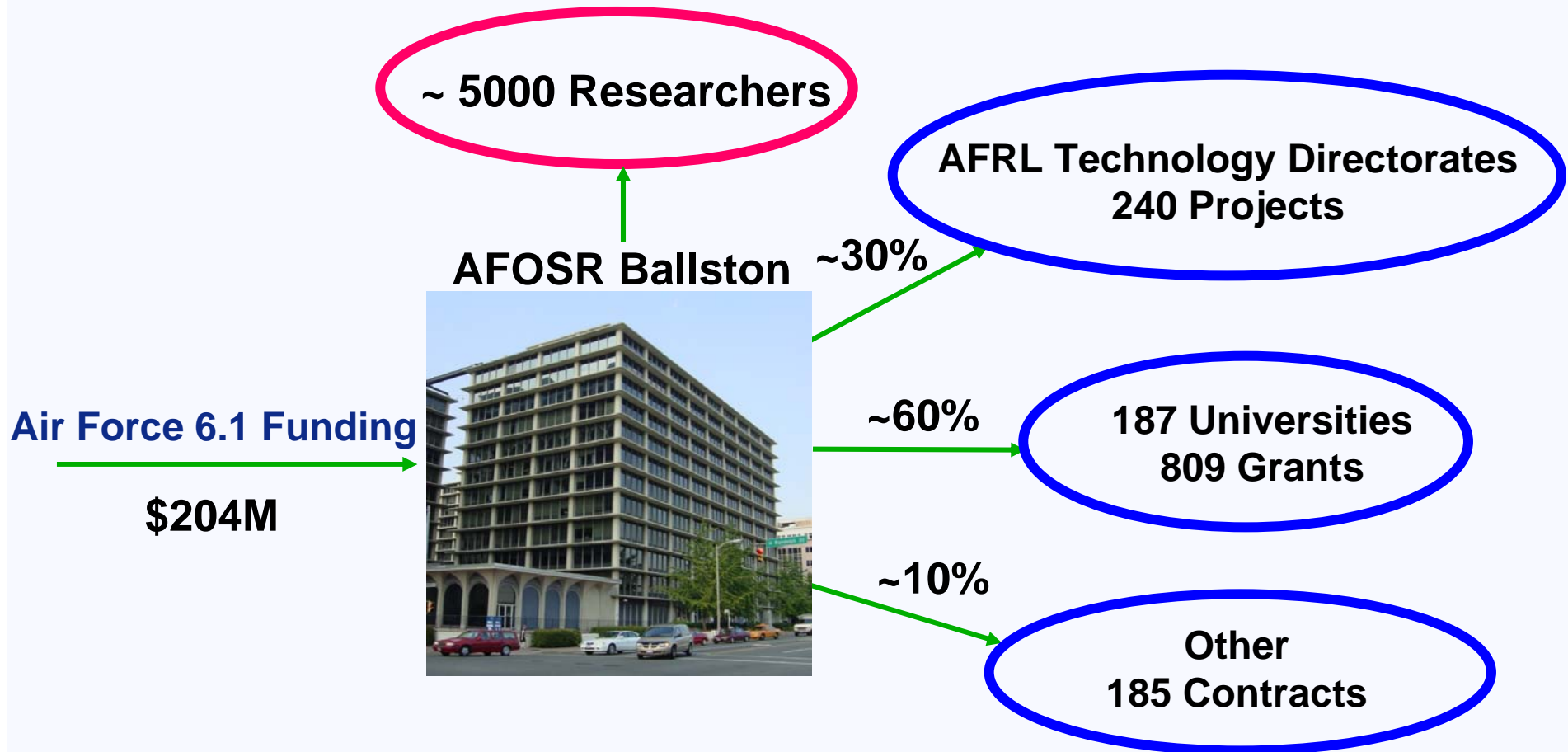


- **Encourage and Support Basic Research Supporting AF Needs**
  - Air Force Basic Research Grants and Contracts
  - Multidisciplinary University Research Initiatives
  - Defense University Research Instrumentation Program
  - DARPA and Other Agency Funds
- **Identify and Disseminate Basic Research Discoveries**
- **Educate Tomorrow's S&Es (DOD Education Programs)**
  - National Defense Scientists & Engineers Fellowships
  - Undergraduate Scholarships
- **Leverage Foreign Research**
  - Liaison Offices in Europe and Asia
  - Window on Science – 335 Visitors in FY04
  - Personnel Exchanges

**AFOSR Orchestrates the Air Force Basic Research Program with Universities, Industry, Other Government Organizations, and the AFRL Technical Directorates**



# AFOSR Funding Profile (FY04)





# Recent Scientific Breakthroughs Supported by AFOSR



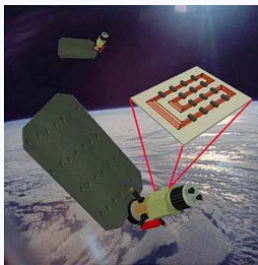
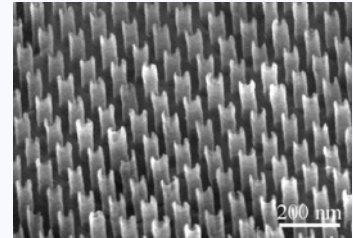
- **Spintronics:** Studying electron spin coherence, ultrafast electronic spin polarizers, and electronic spin manipulation • Implications for all aspects of information processing technology
- **Left-Handed Materials:** Developing magnetic composites negative indices of refraction • Wide range of potential applications (antenna, microwave devices, shielding)
- **Electromagnetics:** Studying the propagation of modulated EM radiation by dispersive media • Potential new strategy to reveal hidden targets
- **Polynitrogen Chemistry:** Computational methods used to aid synthesis of new all-nitrogen compounds • First new all-nitrogen species,  $N_5^+$ , in over 100 years • Studying reactivity and compatibility of compounds
- **Biomimetics:** Examining morphology and physiology associated with infrared detection in pit vipers and pythons • Potential room-temperature IR detection
- **Nanotechnology:** Investigating novel phenomena, properties and functions that occur on the nanoscale • Invention of dip-pen nanolithography



# FY06 POM Initiatives Support AFRL Nanotechnology Initiative

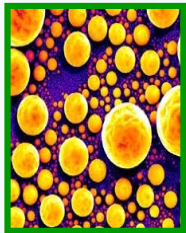
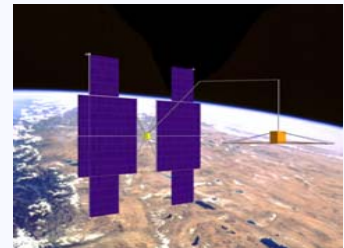


**Nanoelectronics: Multispectral Detector Arrays:** Explore techniques to control growth of self-assembled quantum structures, connections to the structures, and combinations of both, which will lead to detectors for multispectral and hyperspectral image processing.



**Nanoelectronics: Chip Scale Optical Networks:** Forward-looking architectural effort that seeks to develop new concepts in the design, operation, employment, and overall functioning of military platform networks.

**Nanoelectronics: Compact Power for Space:** Increase specific power for solar arrays, fuel cells, and power storage systems for high power space platforms.



**Nanoenergetics:** Enable the development of higher performance, less-sensitive nanoscale energetic materials for applications in munitions and propulsion.

**Nanomaterials for Structures:** Establish nanomaterial and nanocomposite systems that will enable reduced system weight or size, increased operational lifetime, and multifunctional performance of load-bearing aerospace structures.



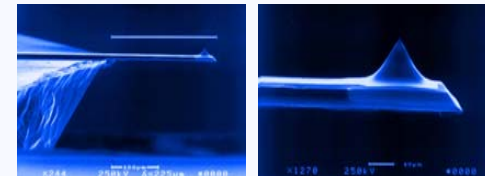




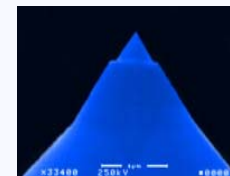
# Overview of AFRL Nanoscience and Nanotechnology Interest



- Materials Area
  - Tailorable Dielectrics
  - Reconfigurable Optical Response
  - Adaptive Structural Materials
  - Thermal Control Materials
- Energy Area
  - Energetics on the Nanoscale
  - Nano-enhanced Power Technologies
- Devices Area
  - Quantum Confined Optical Sensors
  - Nanotechnology for RF
  - Nano Signal Processors
- Bio-Nano Area
  - Bio Interactions of Nanostructures
- Cross-Cutting (foundations)
  - Self-assembly of Nanostructures
  - Nano-Micro-Macro Interfaces
  - Modeling And Simulation



Nanoprobes







# Taiwan – AFOSR Nanoscience Initiative



- Natural extension of common interest
- Founded in recognition of Taiwan's commitment to establishing itself as a world-class technical power in nanoscience and nanotechnology
- Primary goal: To establish mutually beneficial scientific interactions between researchers in Taiwan and AFRL scientists
  - Foster basic research innovation & interactions between scientists
  - Enhance future USAF capabilities through support of Air Force fundamental nanoscience research efforts



# Taiwan Participants Include



- National Science Council
- Academia Sinica
- Industrial Technology Research Institute
- Chung-Shan Institute of Science and Technology
- National Central University
- National Cheng Kung University
- National Chiao Tung University
- National Chung Cheng University
- National Taiwan Normal University
- National Taiwan University
- National Tsing Hua University





# Nanoscience Initiative Summary



- 24 projects total completed / funded / approved
- More than 70 white papers received over life of the program
- 19 visits + 20 proposed visits by Taiwanese researchers to AFRL scientists
- 5 visits by AFOSR to Taiwan
- 3 joint workshops
- Pay-off
  - Relationships established between US & Taiwan researchers
  - Cost effective enhancement of USAF basic research efforts
  - Acquisition of unique basic nanoscience research results

**Taiwan – AFOSR Nanoscience Initiative is delivering many opportunities for interactions between Taiwan and Air Force Research Laboratory researchers**



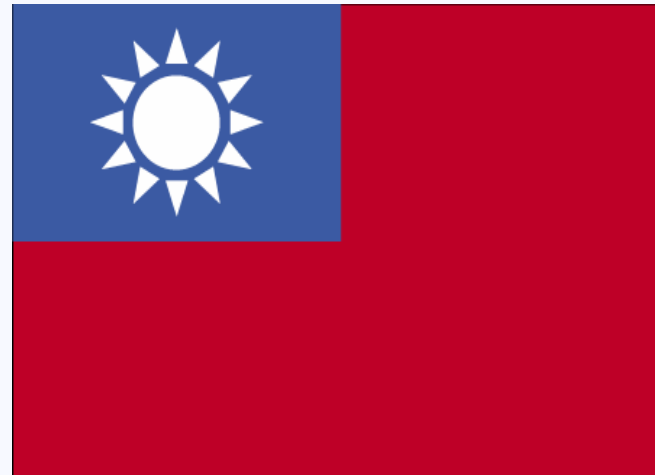
NTU Researchers w/  
AFOSR personnel



# Closing Thoughts – Win-Win Future



- **Nanoscience and nanotechnology Information Exchange Agreement approaching final approval**
- **Congratulations to Dr. Maw-Kuen Wu for his appointment to Director, National Science Council**
- **AFOSR initiatives with Taiwan foster and generate goodwill**
- **Further the scientific goals of the United States and Taiwan**





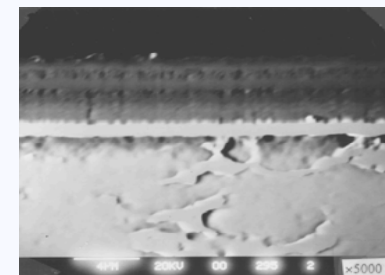
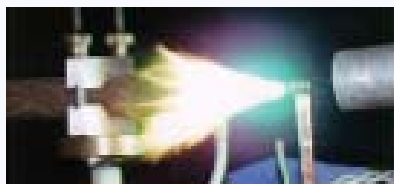
# Backup



# EOARD Highlights



- **Hypersonics: Russia**
  - Leveraging Russian Expertise (Bow Shock Control, Boundary Layer Control, Plasma Fuel Injection, Heat Flux Control, etc.)
  - Technology is Transitioning
- **Hall Effect Thruster (HET): Russia, Spain**
  - HETs Provide Highly Efficient Spacecraft Propulsion (Increased Payload/Decreased Cost)
  - Investigating How to Cluster Multiple HETs for Increased Power
- **Damping Coatings: Ukraine**
  - Seeking to Overcome High Cycle Fatigue Effects on Titanium in Air Force Fighter Engines
  - Investigating Layering Materials on Titanium to Improve Damping





# AOARD Highlights



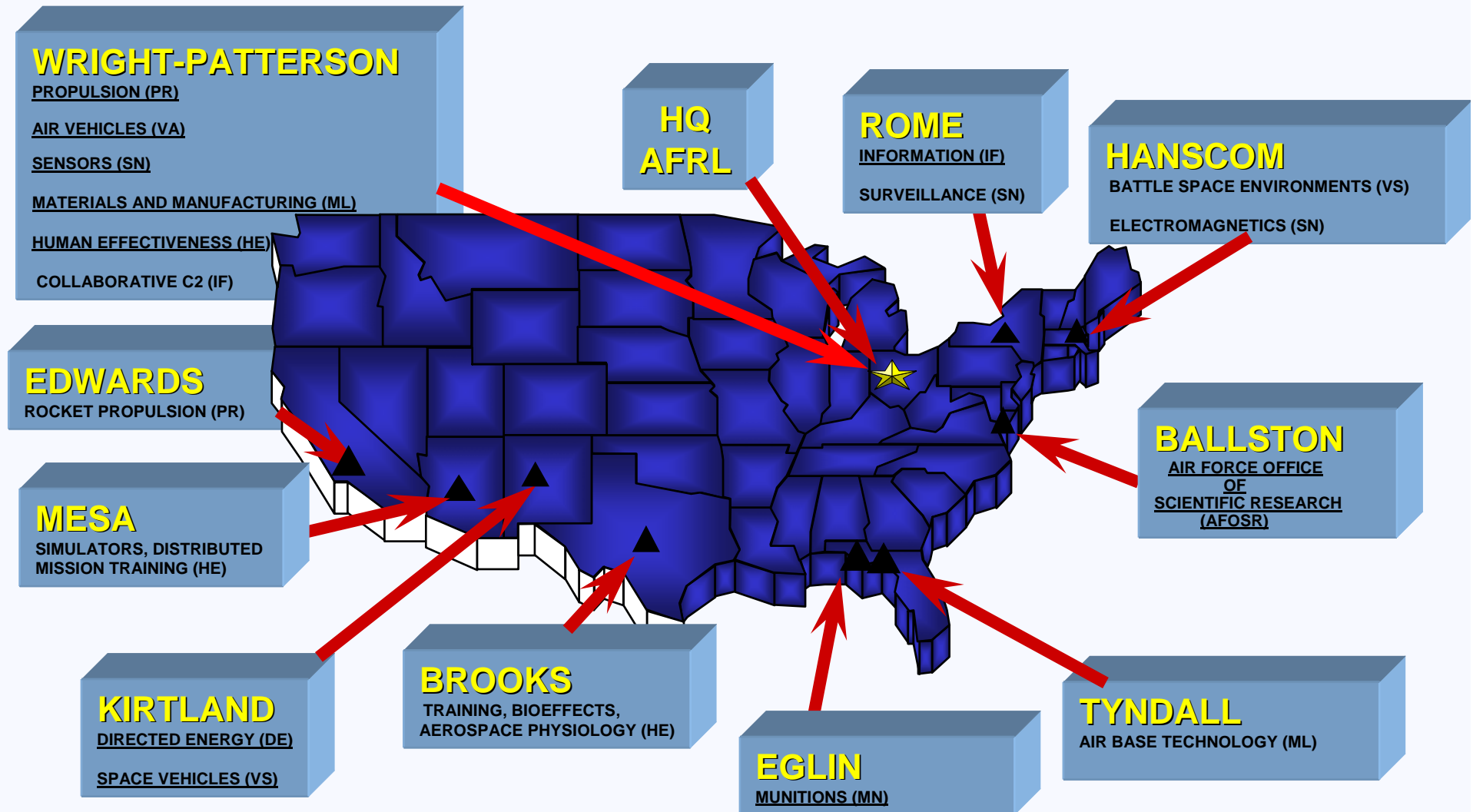
- **Nanoscience Initiatives: Taiwan & Korea**
  - Leveraging Asia's \$1 Billion Nano-science Investment
  - Research Areas Include: Quantum Dots, Polymer Electronics, and Photovoltaics
- **Ionospheric Scintillation Data: Taiwan**
  - Studying Low-latitude Events that Can Interfere with Communications
- **Micro-turbine Research: Japan**
  - Developing Lunch-box Size 100 Watt Power Sources, 10 mm Rotors, High-speed Bearing Technology (1 Million RPM)
- **Hyshot In-flight Scramjet Test: Australia**
  - Leveraged Data from 1<sup>st</sup> In-flight Supersonic Scramjet Combustor Test (Mach 7.5)
  - Initiating Future Collaborative Efforts





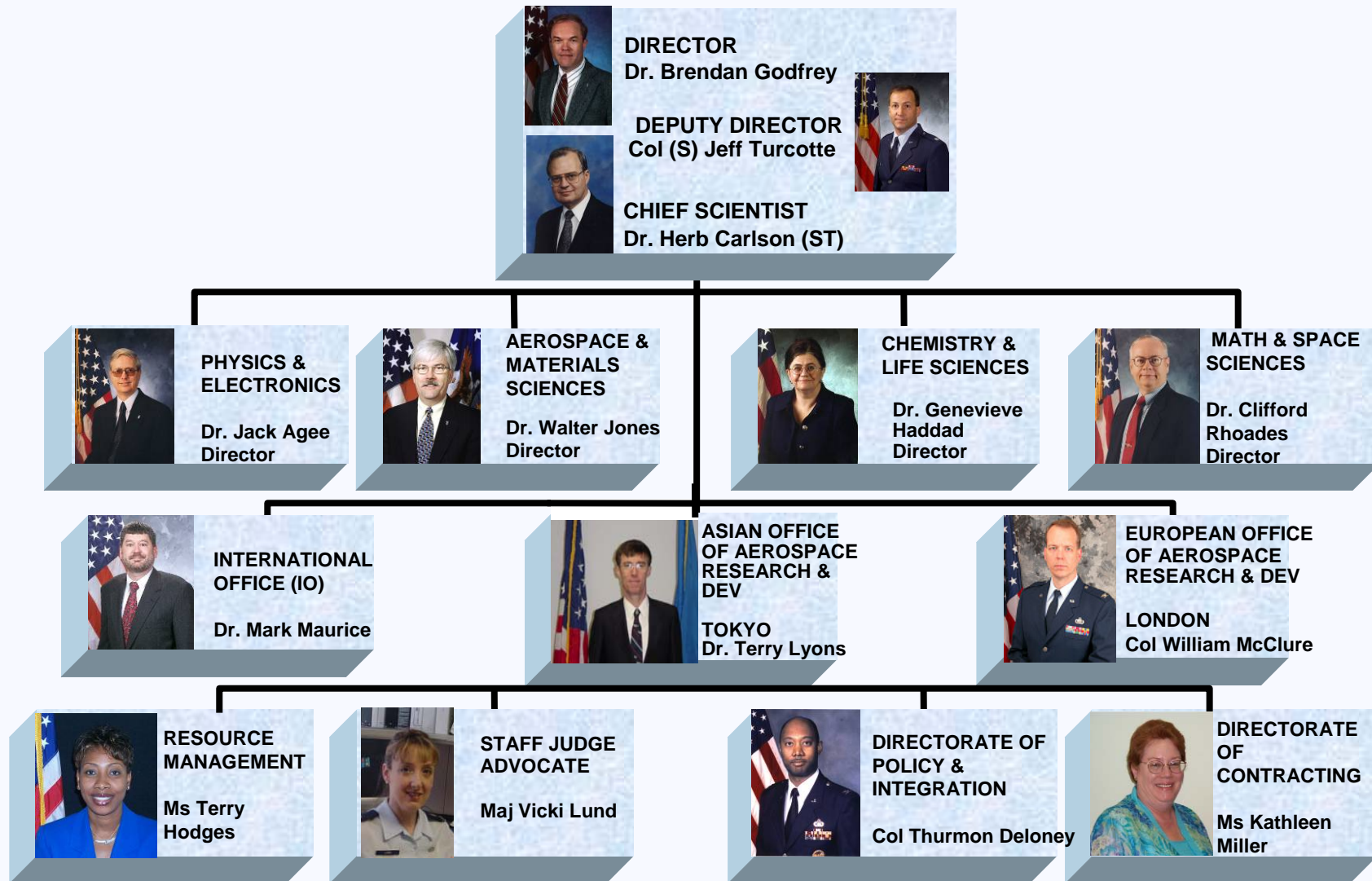


# AFRL Major Sites and Technology Areas





# AFOSR Organization

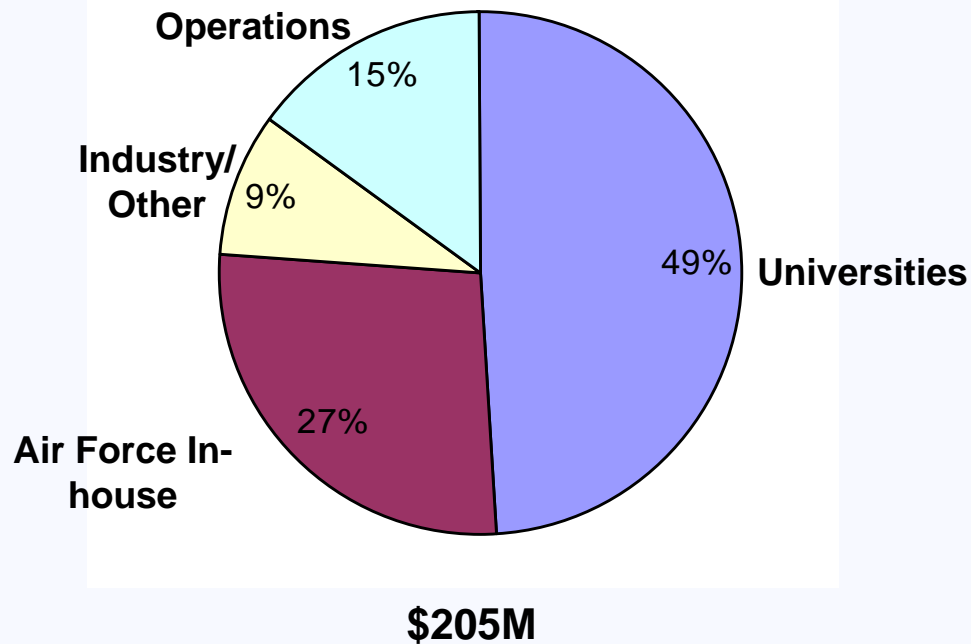




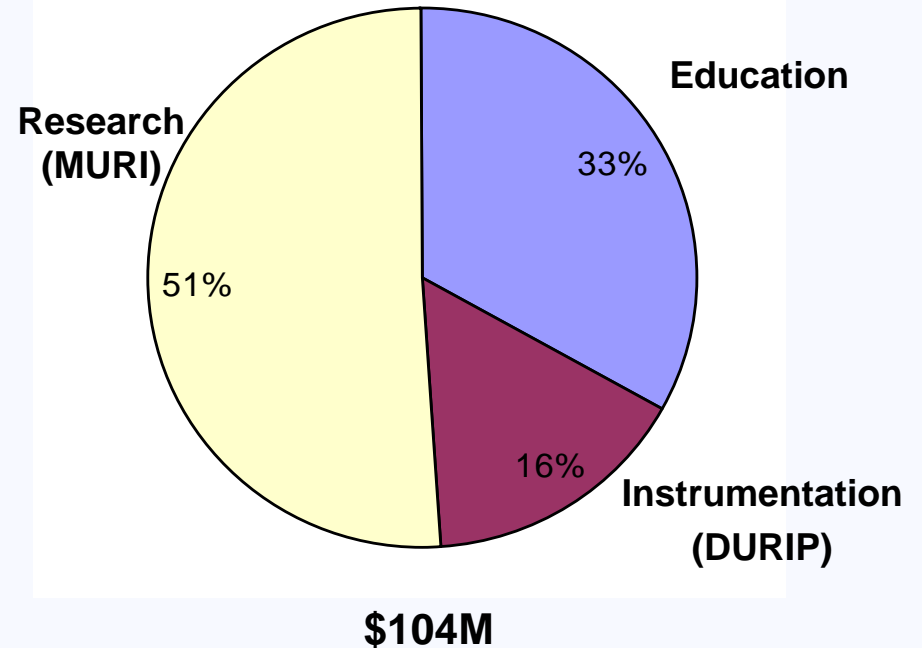
# AFOSR FY2004 Budget Authority



**PE 61102F**  
**Defense Research Sciences**



**PE 61103F**  
**University Research Initiatives (URI)**



AFOSR also Executes ~\$85M for Other Organizations and Programs (STTR, DARPA, etc.)



# AFOSR Supports Tomorrow's Scientists and Engineers



- **Research Grants to Universities**
  - 3000-4000 Graduate Students and Postdocs
- **National Defense Science and Engineering Graduate (NDSEG) Fellowships**
  - 452 PhD-track Graduate Students
- **Awards to Stimulate and Support Undergraduate Research Experience (ASSURE)**
  - 480 Undergraduate Students
- **Junior Science and Humanity Symposium (JSHS)**
  - 50 Scholarships for Regional and Final High School Student Winners
- **National Research Council Resident Research Associateships**
  - 25 Postdocs Working in AFRL





# Aerospace and Materials Science



## Technology Foci

- High Cycle Fatigue
- Smart Skins/Adaptive Wings
- Structural Mechanics
- Metallic Materials
- Ceramic and Non-Metallic Materials
- Organic Matrix Composites
- Unsteady Aerodynamics
- Turbulence and Rotating Flows
- Space Power and Propulsion
- Combustion and Diagnostics

## Relevant Capability

- Reduce engine fatigue
- Increase Lift/Drag ratio
- Reduce aerospace vehicle weight
- Increase engine thrust to weight ratio
- Eliminate materials reliability issues
- Expand flight envelope and enhance maneuverability
- Minimize events of engine stall
- Reduce hypersonic drag
- Provide low cost, more flexible space access
- Streamline aircraft and rocket propulsion system design



# Physics and Electronics



## Technology Foci

- Lasers and Optical Physics
- Atomic and Molecular Physics
- Plasma Physics
- Space Electronics, Sensors and Propulsion
- Optoelectronic Information Processing
- Semiconductor Materials
- High Power Microwaves

## Relevant Capability

- Processing speeds orders of magnitude faster than today
- Recovery of images through atmospheric turbulence
- Greater radiation tolerance
- 1000 times improvement in data storage
- Expanded transmission bandwidth
- Real-time adaptive signal and image processing
- Electronic warfare and non-lethal effects



# Chemistry and Life Sciences



## Technology Foci

- All-Nitrogen Propellants
- Theoretical Chemistry
- Polymer Chemistry
- Biomimetic Sensors
- Chronobiology and Neural Adaptation
- Information Fusion
- Perception and Cognition
- Switchable, Tunable Optical Filters
- Adaptive Bio-Materials

## Relevant Capability

- Energetic materials for propellants and explosives
- Ten times more powerful chemical lasers
- New polymer materials
- Biomimetically enhanced sensors
- Strategies to reduce fatigue
- Command & control decision making
- Better personnel training, selection, and classification
- Versatile laser protection
- New class of highly functional light weight polymeric materials





# Mathematics and Space Sciences



## Technology Foci

- Dynamics and Control
- Physical Mathematics and Applied Analysis
- Computational Mathematics
- Optimization and Discrete Mathematics
- Systems, Software, and Reliability
- Artificial Intelligence
- Electromagnetics
- Space Physics and Solar Phenomena
- Spectral Imaging
- Upper Atmosphere Laser Beam Propagation

## Relevant Capability

- Modeling of complex problems and systems
- Control of vibrations and shape of space structures
- Better vehicle performance and control
- New methods for target acquisition and recognition
- Detection avoidance
- Timely management of information
- Improved solar and space environment forecasting
- Protection of space assets
- ID Targets Under Trees
- ABL targeting through turbulence



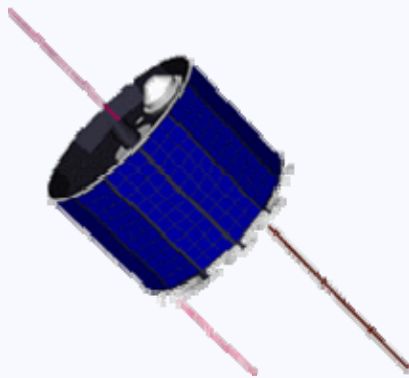
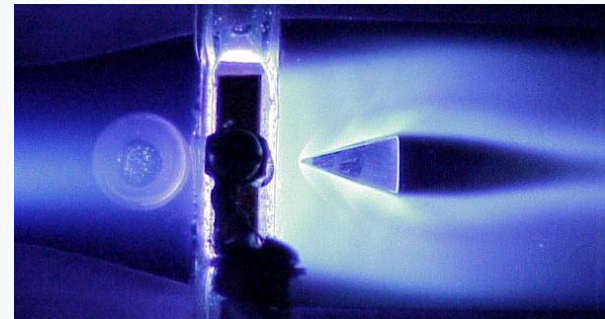
# AFOSR Themes



Multi-Mission Reconfigurable  
Assets  
Undeniable  
Communication

**Cooperative Control:** Develop fundamental theory, algorithms, and software to design and analyze robust, high-performance, team-based, multi-agent cooperative control systems operating in dynamic, uncertain adversarial environments

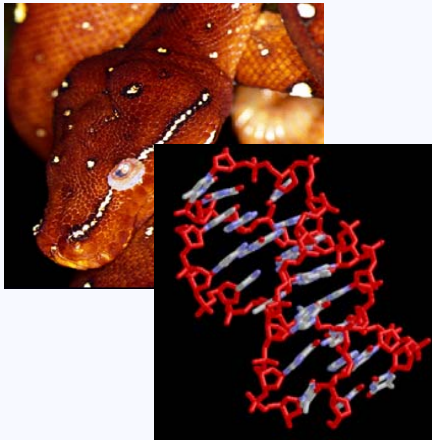
**Plasma Dynamics:** Understand, predict, and control weakly ionized flows to revolutionize the performance of aerospace vehicles



**Miniaturization Science for Space:** Enable much lighter, more compact, microsatellites, nanosatellites & picosatellites



# AFOSR Themes



**Biologically Inspired Concepts:** Provide biologically inspired technology by exploring living systems down to molecular level

- Develop chemical models & engineering concepts

**Type II Quantum Computation:** Develop near-term quantum computer implementations • Develop algorithms to model physical systems • Explore architectures to scale a large array of small quantum computers



**Materials Engineering** Exploit computational materials science and engineering to develop techniques for coupling models of material behavior • Enable materials design to be an integral part of the global design process