

Air Force Office of Scientific Research Overview



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

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Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 06 DEC 2005		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Air Force Office of Scientific Research Overview				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Office of Scientific Research 875 N. Randolph St., Suite 325, Arlington, VA 22203-1768				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM201995., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 24	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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

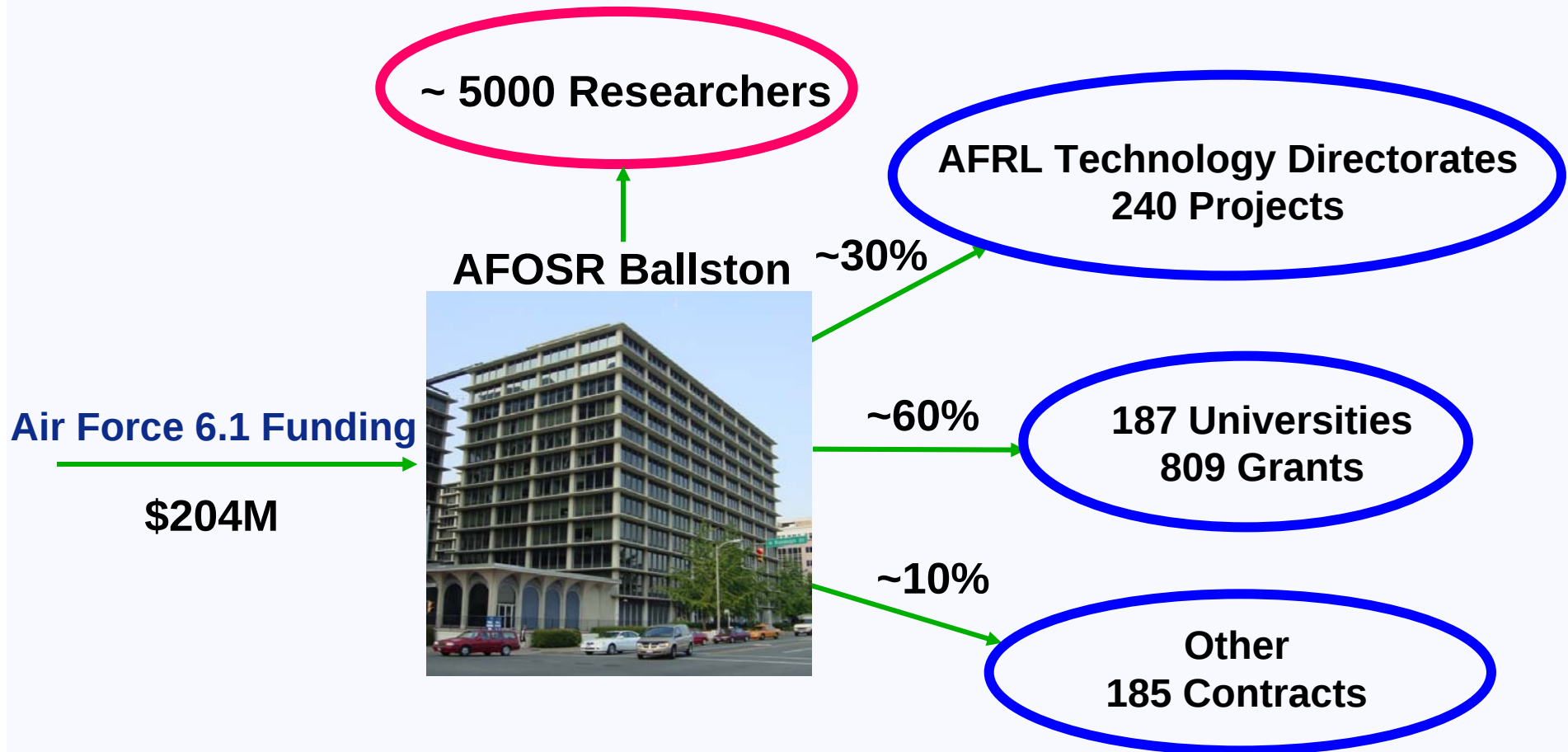


- **Encourage and Support Basic Research Supporting AF Needs**
 - Air Force Basic Research Grants and Contracts
 - Multidisciplinary University Research Initiatives
 - Defense University Research Instrumentation Program
 - DARPA and Other Agency Funds
- **Identify and Disseminate Basic Research Discoveries**
- **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



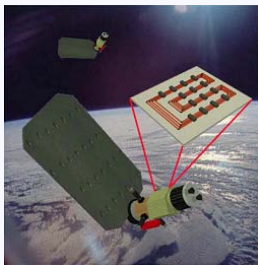
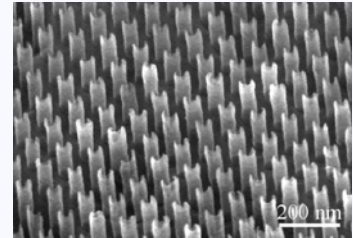
- **Spintronics:** Studying electron spin coherence, ultrafast electronic spin polarizers, and electronic spin manipulation • Implications for all aspects of information processing technology
- **Left-Handed Materials:** Developing magnetic composites negative indices of refraction • Wide range of potential 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

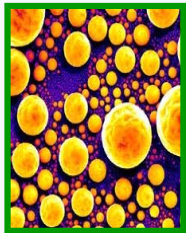
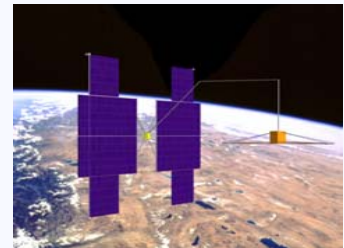


Nanoelectronics: Multispectral Detector Arrays: Explore techniques to control growth of self-assembled quantum structures, connections to the structures, and combinations of both, which will lead to detectors for multispectral and hyperspectral image processing.



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.

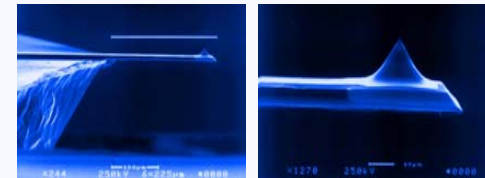




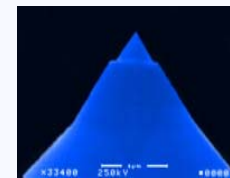
Overview of AFRL Nanoscience and Nanotechnology Interest



- 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

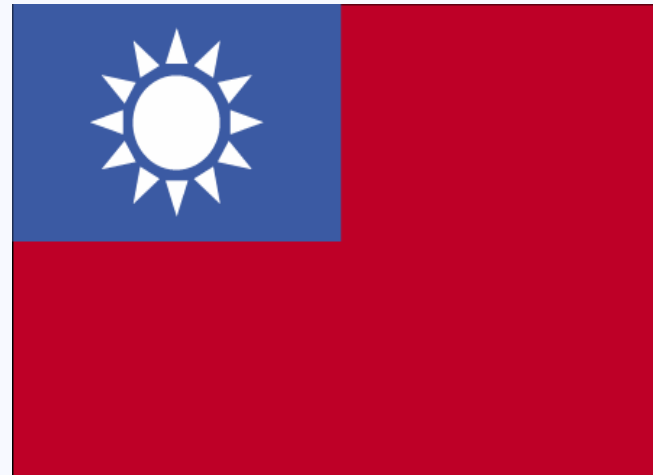




Closing Thoughts – Win-Win Future



- **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**





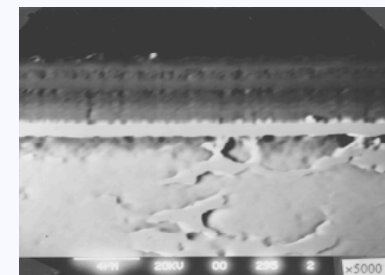
Backup



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

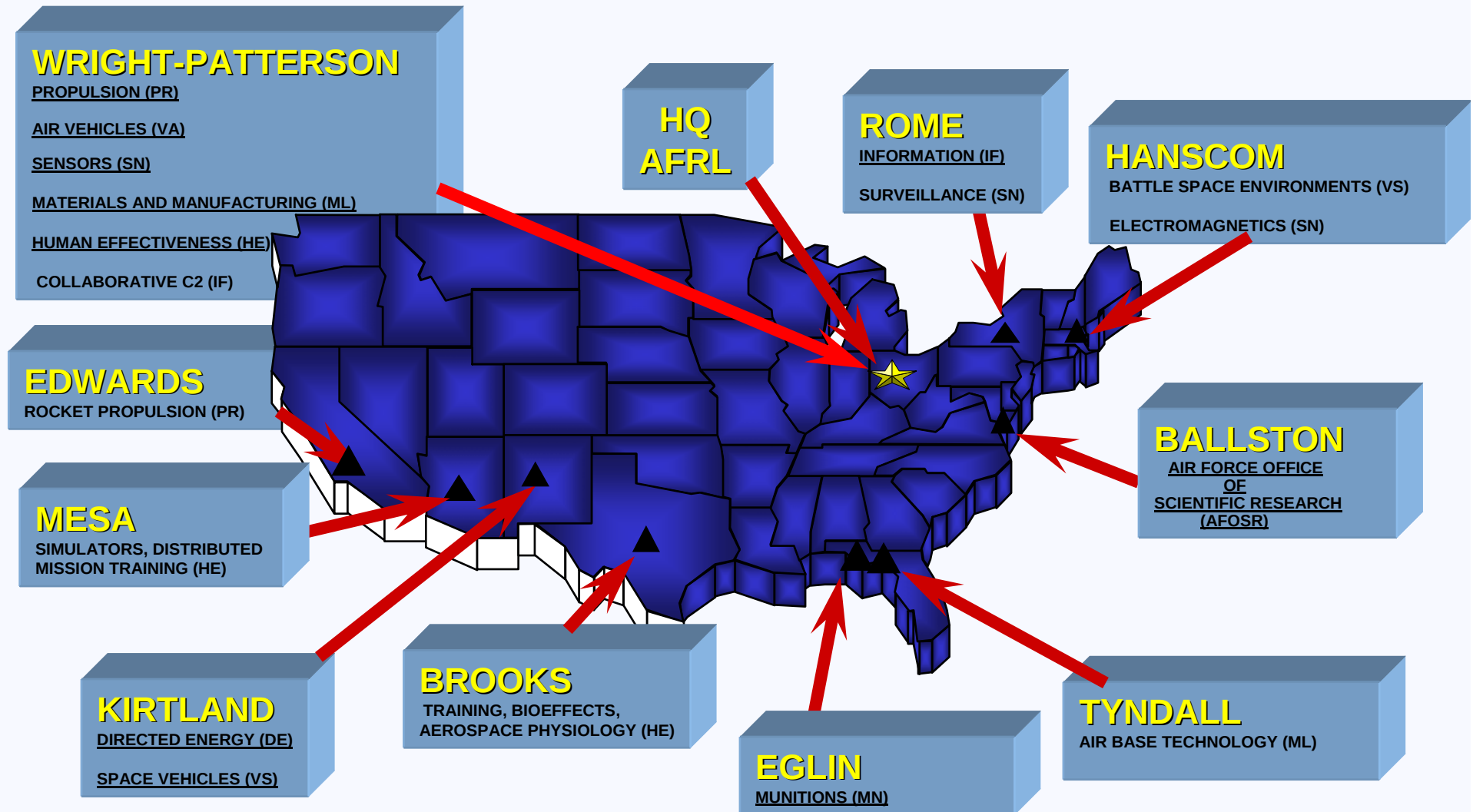


- **Nanoscience Initiatives: Taiwan & Korea**
 - Leveraging Asia's \$1 Billion Nano-science Investment
 - Research Areas Include: Quantum Dots, Polymer Electronics, and Photovoltaics
- **Ionospheric Scintillation Data: Taiwan**
 - Studying Low-latitude Events that Can Interfere with Communications
- **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 1st In-flight Supersonic Scramjet Combustor Test (Mach 7.5)
 - Initiating Future Collaborative Efforts



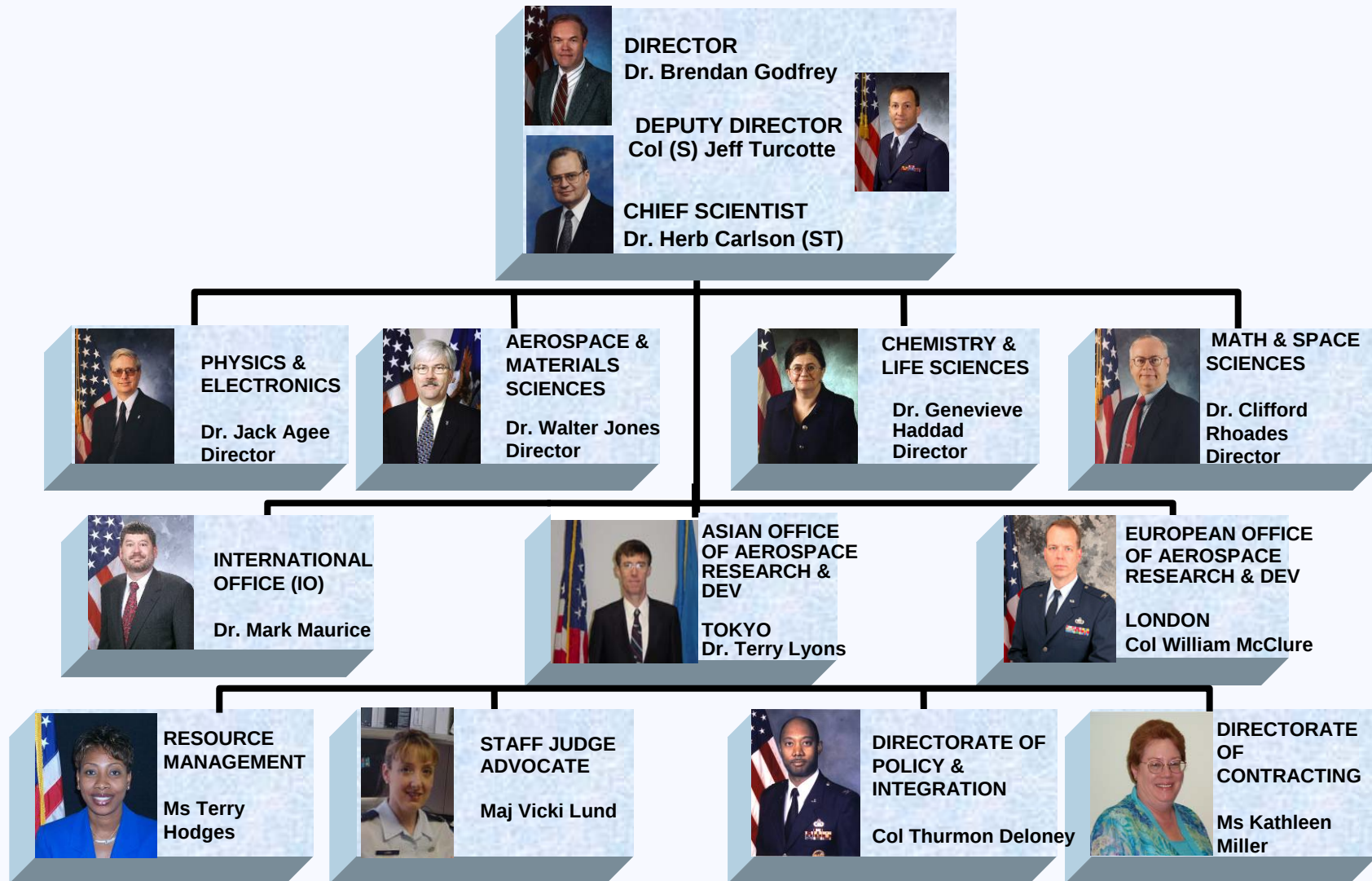


AFRL Major Sites and Technology Areas





AFOSR Organization

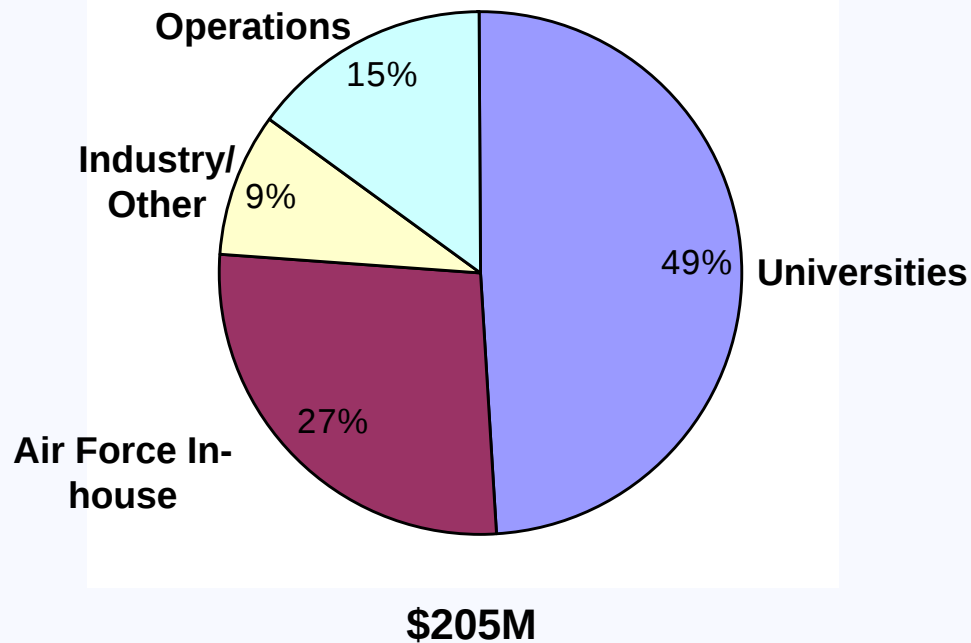




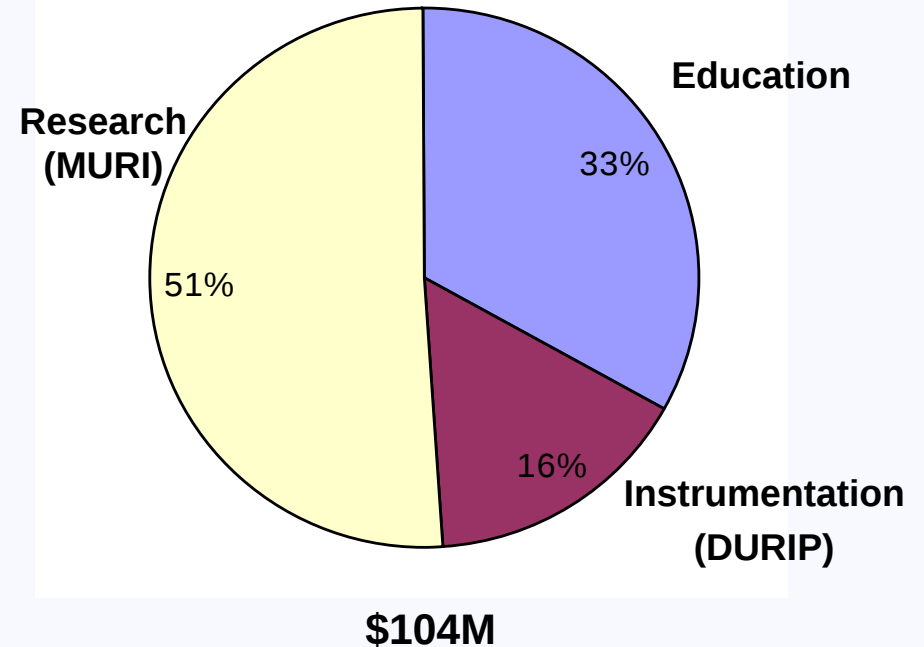
AFOSR FY2004 Budget Authority



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



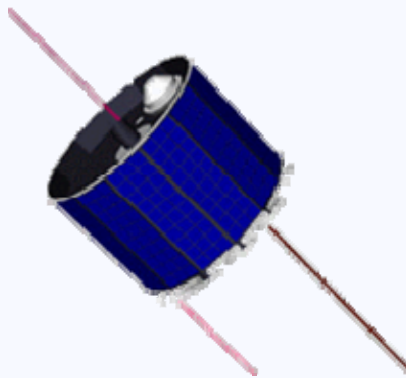
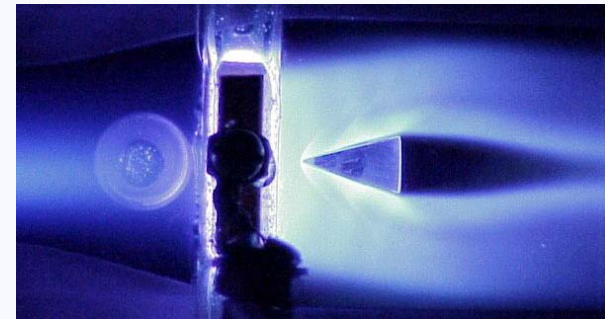
AFOSR Themes



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

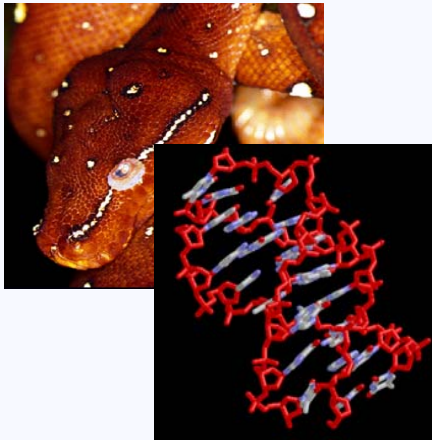
Plasma Dynamics: Understand, predict, and control weakly ionized flows to revolutionize the performance of aerospace vehicles



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