PE NUMBER: 0601102F
PE TITLE: Defense Research Sciences

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

	Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	246.414	241.436	250.232	239.586	256.843	261.460	266.577	Continuing	TBD
2301	Physics	25.701	25.158	27.850	24.751	24.935	25.342	26.832	Continuing	TBD
2302	Solid Mechanics and Structures	13.009	14.139	17.093	15.682	15.959	16.313	16.646	Continuing	TBD
2303	Chemistry	30.465	31.067	32.860	29.562	29.581	29.981	30.081	Continuing	TBD
2304	Mathematics and Computing Sciences	25.147	26.802	31.318	30.980	29.612	30.166	30.685	Continuing	TBD
2305	Electronics	25.646	30.360	33.835	33.163	36.606	37.258	37.855	Continuing	TBD
2306	Materials	17.850	17.753	20.302	20.007	20.418	20.774	21.102	Continuing	TBD
2307	Fluid Mechanics	27.618	12.879	12.070	11.698	11.942	12.173	12.384	Continuing	TBD
2308	Propulsion	16.524	21.729	18.347	18.058	18.477	18.821	19.140	Continuing	TBD
2311	Space and Information Sciences	29.553	30.488	27.005	25.489	25.368	25.829	26.255	Continuing	TBD
2312	Biological Sciences	9.437	9.687	10.052	10.501	10.774	10.974	11.159	Continuing	TBD
2313	Human Performance	13.183	13.687	10.804	10.650	14.725	15.014	15.281	Continuing	TBD
4113	External Research Programs Interface	12.281	7.687	8.696	9.045	18.446	18.815	19.157	Continuing	TBD

Note: Funds for FY 2006 Congressionally-directed Fully-Integrated Solar-Powered Interior Lighting Technology in the amount of $1.0 million are in the process of being moved to PE 0602102F, Materials, from PE 0601102F, Defense Research Sciences, for execution. Funds for FY 2006 Congressionally-directed National Aerospace Leadership Initiative in the amount of $21.0 million are in the process of being moved to PE 0601102F, Defense Research Sciences, from PE 063211F, Aerospace Technology Development and Demonstration, for execution. Funds for FY 2006 Congressionally-directed Notre Dame Center for Flow Physics and Control in the amount of $3.0 million are in the process of being moved to PE 0601102F, Defense Research Sciences, from PE 062203F, Aerospace Propulsion, for execution.

(U) A. Mission Description and Budget Item Justification

This program consists of extramural research activities in academia and industry along with in-house investigations performed in the Air Force Research Laboratory. This program funds fundamental broad-based scientific and engineering research in areas critical to Air Force weapon systems. Projects are coordinated through the Defense Reliance process to harmonize efforts, eliminate duplication, and ensure the most effective use of funds across the Department of Defense. All research areas are subject to long-range planning and technical review by both Air Force and tri-Service scientific planning groups. Note: In FY 2006, Congress added $1.0 million for Fully-Integrated Solar-Powered Interior Lighting Technology; $0.75 million for Non-Lethal Stunning/Immobilizing Weapons; $1.4 million for Corrosion Protection of Aluminum Alloys Used in Aircraft; $1.8 million for Nanophotonic Components; $2.0 million for National Hypersonic Research Center; $5.0 million for Coal-Based Fuel; $1.0 million for Griffith Observatory's Planetarium; $4.6 million for Network Information and Space Security Center; and $3.5 million for Virtual Operation for Unmanned Aerial Vehicles. This program is in Budget Activity 1, Basic Research, because it funds scientific study and experimentation. Through this program, the Air Force invests in research directed toward increasing knowledge and understanding in those fields of science and engineering related to long-term national security needs.

Exhibit R-2, RDT&E Budget Item Justification	DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**

(U) B. Program Change Summary ($ in Millions)

		FY 2005	FY 2006	FY 2007
(U)	Previous President's Budget	252.113	223.894	245.595
(U)	Current PBR/President's Budget	246.414	241.436	250.232
(U)	Total Adjustments	-5.699	17.542	
(U)	Congressional Program Reductions	0.000	-0.016	
	Congressional Rescissions	-0.204	-3.492	
	Congressional Increases	0.000	21.050	
	Reprogrammings	-2.804		
	SBIR/STTR Transfer	-2.691		

(U) Significant Program Changes:

Not Applicable.

C. Performance Metrics

(U) Under Development.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2301 Physics

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2301 Physics	25.701	25.158	27.850	24.751	24.935	25.342	26.832	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Physics basic research seeks to enable revolutionary advances in and expand the fundamental knowledge supporting laser technologies, sensing, and imaging capabilities, communications and navigational systems, fuels and explosives, and directed energy weapons that are critical to the Air Force. The primary areas of research investigated by this project are laser and optical physics; electro-energetics (includes plasma) physics; atomic, molecular, and particle physics; and space sensors and imaging physics.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and multi-aperture adaptive optics.	8.144	8.237	9.573
(U) In FY 2005: Continued investigating physical properties of lasers to enable, monitor, and regulate tunable, wide wavelength band lasers (e.g., solid state, free electron, fiber). Investigated novel tomographic and optical techniques tied to large, multi-aperture, adaptive telescopes and radars. Expanded studies of novel laser micro-and nano-machining techniques and their applications to new materials with desirable space and electronic properties. Explored laser applications for infrared countermeasures.			
(U) In FY 2006: Continue investigating physical properties of lasers to enable, monitor, and regulate tunable, wide wavelength band lasers. Continue investigating novel tomographic and optical techniques tied to large, multi-aperture, adaptive telescopes and radars. Explore use of directed energy beams for direct-write materials-processing techniques that offer new microelectronics and micromechanics fabrication and packaging capabilities. Continue to examine laser applications for infrared countermeasures.			
(U) In FY 2007: Further investigate new laser materials and configurations to enable efficient, high power, and widely wavelength tunable lasers. Investigate arrays of micro-discharges for laser devices and pumps, as well as other intense light source applications. Further explore use of directed energy beams for direct-write materials processing techniques that offer new microsystems fabrication and packaging capabilities. Continue to study semiconductor laser and nonlinear optical devices for improved application to infrared countermeasures.			
(U)			
(U) MAJOR THRUST: Explore high-energy, electro-energetic device concepts and manipulate atomic and molecular properties, atomic collision processes, and atomic, molecular, ionic, and radiation interactions to improve explosives and fuels, advance directed energy systems, enhance surveillance, provide superior communications, and improve precision navigation.	10.964	11.056	13.520
(U) In FY 2005: Continued to characterize interactions of atoms and molecules in strong electromagnetic fields for laser			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2301 Physics**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	applications. Examined techniques for precision measurement of atomic and molecular properties, atomic collision processes, and fundamental interactions between atoms, molecules, ions, and radiation. Explored advances in high-resolution spectroscopy via the trapping and cooling of atoms and ions. Continued exploring dynamic molecular interactions in combustion and high energy density propellants. Continued examining materials, surfaces, and air breakdown in the presence of strong electric and sub-meter wave fields. Continued plasma physics studies in the areas of all-electric military platforms, high-bandwidth communications, and advanced long-distance covert surveillance. Continued probing the effects of short-pulse intense electric fields on cells and organelles.			
(U)	In FY 2006: Continue to characterize interactions of atoms and molecules in strong electromagnetic fields. Continue to examine techniques for precision measurement of atomic and molecular properties, atomic collision processes, and fundamental interactions between atoms, molecules, ions, and radiation. Continue exploring dynamic molecular interactions in combustion and high energy density propellants. Continue studies on the stunning effects of short-pulse, high intensity electric fields. Continue explorations of high power, high frequency device concepts and studies of new compact pulsed power technologies. Explore use of electron beam generated microwave for, high-bandwidth communications, advanced long-distance covert surveillance, electronic countermeasures, and directed energy weapons. Expand studies of new technologies for generating very high current-density electron beams under high vacuum conditions for new generations of high power microwave weapons concepts. Use atomic physics to study overlap research areas between atomic physics and condensed matter physics (e.g., the study of many body phenomena).			
(U)	In FY 2007: Continue characterizing the interactions of atoms and molecules in strong electromagnetic fields. Continue to examine techniques for precision measurement of atomic and molecular properties, atomic collision processes, and fundamental interactions between atoms, molecules, ions, and radiation. Continue exploring dynamic molecular interactions in combustion and high energy density propellants. Continue studies on electro-energetic concepts related to non-lethal weaponry. Continue explorations of high power, high frequency electromagnetic device concepts and studies of new compact pulsed power technologies. Continue to explore the use of electron beam generated microwaves for high-bandwidth communications, advanced long-distance covert surveillance, electronic countermeasures, and directed energy weapons. Investigate ultra-high current density cathode concepts. Initiate advanced modeling and simulation of electro-energetic phenomena. Continue study of overlap research areas between atomic physics and condensed matter physics. Resolve basic scientific issues blocking realization of electromagnetic launch concepts.			
(U)				
(U)	MAJOR THRUST: Advance technologies for space sensors, imaging, identification, and tracking methods, and effective space situational awareness.	4.045	4.139	4.757

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2301 Physics**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	In FY 2005: Probed effects of atmospheric and space environments on sensors and energy (i.e., information) propagation. Identified, characterized, and modeled parameters enabling remote sensing, locating, and precision tracking of objects in and from space. Evaluated tools and enhanced system interactions for enabling effective space situational awareness.			
(U)	In FY 2006: Continue studying fundamental issues of atmospheric and space environments concerning remote sensing, including propagation, image formation, and image recovery processes. Continue to identify, characterize, and model parameters enabling remote sensing, locating, and precision tracking of objects, particularly from space and of space objects from the ground.			
(U)	In FY 2007: Continue studying fundamental issues that affect remote sensing, including propagation, image formation, and image recovery processes. Continue to identify, characterize, and model parameters enabling remote sensing, locating, and precision tracking of objects, particularly from space and of space objects from the ground. Further study of environmental effects on sensors and sensor systems and of the effects of the medium through which the signal propagates.			
(U)				
(U)	CONGRESSIONAL ADD: Non-lethal Stunning/Immobilizing Weapons	0.490	0.740	0.000
(U)	In FY 2005: Continued accelerated efforts in conducting fundamental scientific investigations in non-lethal stunning and immobilizing weapons research.			
(U)	In FY 2006: Contintue to investigate non-lethal weaponry utilizing radio frequency/microwave radiation.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Microwave Vacuum Electronics Power Research Initiative	2.058	0.000	0.000
(U)	In FY 2005: Re-established a joint industry-university program for research into Microwave Vacuum Engineering (MVE) and High Power Microwave (HPM) technology.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Fully-Integrated Solar-Powered Interior Lighting Technology	0.000	0.986	0.000
(U)	In FY 2005: Not Applicable.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Fully-Integrated Solar-Powered Interior Lighting Technology.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	25.701	25.158	27.850

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2301 Physics**

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602204F, Aerospace Sensors.									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0602605F, Directed Energy Technology.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2302 Solid Mechanics and Structures

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2302 Solid Mechanics and Structures	13.009	14.139	17.093	15.682	15.959	16.313	16.646	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Solid mechanics and structures basic research aims to improve load-bearing performance of air and space structures through the prediction and control of multi-scale phenomena ranging from micro-level deformation and fracture of materials to the structural dynamics of large platforms. The goals are cost-effective development and safe, reliable operation of superior Air Force weapon and defensive systems. Fundamental knowledge of "multi-functional" structures with smart materials, sensors, actuators, and control systems integrated to accomplish damage control, thermal management, vibration reduction, and reconfigurable shapes. Research topics include: the modeling of non-linear static/dynamic behavior of structures; mechanical reliability of micro-devices; design of multi-functional materials; mechanical behavior of nano-materials; and composite materials for structures.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Explore the integration of advanced materials (including nano-materials) and devices into turbine engines, air vehicles, space systems, and other weapon systems, and develop new mechanics criteria for system integration.	6.165	6.986	8.071

(U) In FY 2005: Advanced research in the mechanics of materials and devices, with continued focus in the areas of multi-functional design, diagnostics, prognostics, self-healing, micro-/nano-mechanics, autonomics, thermal management, and energy harvest. Investigated methods to combine information technology and multi-scale modeling in the design of new materials and structures. Continued nano-mechanics research to promote the transition from continuum mechanics to atomistic modeling.

(U) In FY 2006: Continue research in the areas of diagnostics, prognostics, self-healing, micro-/nano-mechanics, autonomics, and thermal management to enable safer and more durable aerospace structures with improved performance characteristics. Continue research on the autonomics to include the integration of energy harvesting/storage functions into load-bearing structures. Support research to develop the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Develop and exploit methods that combine information technology and modeling in the design of new material systems and devices at multiple scales.

(U) In FY 2007: Expand research in the areas of diagnostics, prognostics, self-healing, micro-/nano-mechanics, autonomics, thermal management, atomic-scale modeling, and energy harvesting to enable safer and more durable aerospace structures with improved performance characteristics. Further develop the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Continue developing and exploiting methods that combine information technology and modeling in the design of new material systems and devices at multiple scales.

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2302 Solid Mechanics and Structures

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)				
(U)	MAJOR THRUST: Analyze structural fatigue and mechanics, adaptive structures, and material properties to improve the design, robustness, and performance of air and space systems to include multi-mission unmanned aerial vehicles (UAVs).	6.844	7.153	9.022
(U)	In FY 2005: Continued to examine and analyze structural mechanics to include fatigue, integrity, high cycle metal fatigue, and other material aging phenomena. Investigated metal fatigue-generation caused by the vibration of compressors and turbine blades. Continued assessing means and models to identify, evaluate, and mitigate material degeneration and degradation. Continued developing novel system techniques to analyze vehicle integrity. Advanced models of interaction between UAV structural motion and high-speed aerodynamics. Characterized distributed sensor and actuator systems. Explored the mechanical and dynamic behavior of micro-/nano-scale structures.			
(U)	In FY 2006: Explore methods for constructing and modeling morphing structures that broaden system operational capabilities. Develop novel actuation devices and materials for applications such as micro-UAV aircraft and space structures. Continue to investigate metal fatigue-generation caused by the vibration of compressors and turbine blades. Develop structural health monitoring techniques and systems. Continue to explore the mechanical and dynamic behavior of micro-/nano-scale structures. Explore the exploitation of nonlinear phenomena, such as structural deformation and aero-elastic effects in novel structural applications.			
(U)	In FY 2007: Continue to explore novel methods for constructing and modeling morphing structures that broaden system operational capabilities. Continue development of novel actuation devices and materials for applications such as micro-UAV aircraft and space structures. Utilize acquired knowledge of material behavior in aerospace structure to develop system lifetime prognosis methodologies. Continue development of structural health monitoring techniques and systems and exploration of mechanical and dynamic behavior of micro-/nano-scale structures. Continue investigation of nonlinear phenomena, such as structural deformation and aero-elastic effects in novel structural applications.			
(U)	Total Cost	13.009	14.139	17.093

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602201F, Aerospace Flight Dynamics.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2302 Solid Mechanics and Structures**

(U) C. Other Program Funding Summary ($ in Millions)

(U) PE 0602202F, Human Effectiveness Applied Research.

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2303 Chemistry	

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2303 Chemistry	30.465	31.067	32.860	29.562	29.581	29.981	30.081	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Chemistry basic research seeks bold innovations in understanding, modeling, and controlling chemical reactions for developing new materials, improving synthesis of existing materials, controlling energy flow and storage, and regulating interactions between materials and their environments. Studies expand fundamental understanding of properties regulating the chemical dynamics and energy transfer processes that foster advances in laser weaponry and allow predictions of the infrared, optical, and radar signatures of reaction products and intermediates that advance reliable target assessment and tracking. Critical research topics include: novel synthesis and characterization of lower cost, higher performance functional and structural materials, electronics, and photonic materials; nano-structures; electromagnetics; and conventional weaponry. Focused investigations include bio-derived mechanisms for lifetime extension of materials and catalysis, and the exploration of atomic and molecular surface interactions that limit performance of electronic devices, compact power sources, and lubricant materials. Primary areas of research include molecular reaction dynamics; theoretical chemistry; polymer chemistry; biophysical mechanisms; and surface and interfacial science.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Research and characterize molecular dynamics, reaction mechanics/interactions, and theoretical chemistry to model, predict, control, and exploit atomic and molecular energetics for advanced fuels, munitions, and countermeasure techniques.	13.064	13.118	14.947

(U) In FY 2005: Explored ion and plasma chemistry for combustion control applications. Investigated nano-structure concepts and models for propulsion and munition reactive energetics. Continued modeling chemically reacting flows associated with hypersonic vehicles, hydrocarbon-fueled scramjets, and combined-cycle engines. Continued to optimize chemical properties enriching high energy lasers, advancing high-energy, high density fuels and materials, enhancing space lift, and extending time-on-orbit/station.

(U) In FY 2006: Utilize theoretical chemistry to predict promising new chemicals of interests to the Air Force and to guide their efficient synthesis. Enhance efforts to develop higher performance, less sensitive nano-scale energetic materials for applications in munitions and propellants. Support research to understand, predict, and control the reactivity and flow of energy in molecules to improve exhaust signature detection and control capabilities, to develop new high-energy, high density chemicals for propellants and propulsion systems and to develop new high-energy chemical laser systems.

(U) In FY 2007: Continue to utilize theoretical chemistry to predict promising new chemicals of interests to the Air Force and to guide their efficient synthesis. Continue to advance research to understand, predict, and control the reactivity and flow of energy in molecules to improve exhaust signature detection and control capabilities, to develop new high-energy, high density chemicals for propellants and propulsion systems, and to develop new high-energy chemical laser systems. Continue efforts to develop higher performance, less sensitive nano-scale energetic materials

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2303 Chemistry

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	for applications in munitions and propellants.			
(U)				
(U)	MAJOR THRUST: Enhance fundamental understanding of polymer chemical structures, reactivity, molecular engineering, processing controls, and materials technologies to develop advanced organic and matrix composites aimed at improving Air Force systems performance and life spans.	8.654	9.537	10.388
(U)	In FY 2005: Designed and characterized conductive polymers, photonic polymers, nano-structures, and bio-inspired polymers. Evaluated nano-composite structures and mechanical properties for potential applications under harsh space environments. Focused on enhancing optical nonlinearity of organic molecules for laser protection applications.			
(U)	In FY 2006: Continue to focus on enhancing optical nonlinearity for laser protection applications. Exploit nanotechnological techniques to develop compact solar arrays, fuels cells, and power storage systems to provide lightweight power sources for space assets. Exploit photorefractive polymer as a medium for wavefront correction in optical communication and imaging.			
(U)	In FY 2007: Continue to utilize nanotechnology to enhance chemical and physical properties of polymers. Continue to exploit photorefractive polymer as a medium for wavefront correction in optical communication and imaging. Continue to explore flexible structures that can provide functions such as sensing, power generation and storage, electronics, and other functionalities for smart skin and multi-functional structures.			
(U)				
(U)	MAJOR THRUST: Expand the fundamental chemistry and physics of surfaces and interfacial processes pertaining to corrosion protection, wear reduction, micro- and nano-assemblies, and power storage for air and space systems.	6.982	7.032	7.525
(U)	In FY 2005: Enhanced theoretical and predictive methods for surface and interfacial chemical processes. Created and characterized novel multi-functional surface structures, coatings, covers, and lubricants. Investigated nano-scale surface structures for enhanced energy-density storage/delivery and chemically directed self-assembled surfaces for sensor, optical, and power applications. Probed electro-chemical behaviors at surfaces and interfacial regions.			
(U)	In FY 2006: Develop theoretical and predictive methods for the fundamental understanding of the structure and reactivity of surfaces and how surfaces interact with their environment at the interface. Investigate phenomena at surface interfaces, including thin film and alloy growth, friction and wear, lubrication, corrosion and degradation, sensing, electrochemical energy storage, and electrochemically induced reaction products and kinetics. Continue to create and characterize novel multi-functional surface structures, coatings, covers, and lubricants. Continue to investigate nano-scale surface structures and systems for electronic, power, and sensing applications.			
(U)	In FY 2007: Continue developing theoretical and predictive methods for the fundamental understanding of the structure and reactivity of surfaces and how surfaces interact with their environment at the interface. Continue to			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2303 Chemistry

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	investigate phenomena at surface interfaces, including friction and wear, lubrication, corrosion and degradation, sensing, electrochemical energy storage, and electrochemically induced reaction products and kinetics. Continue to create and characterize novel multi-functional surface structures, coatings, covers, and lubricants. Investigate novel biophysical mechanisms for catalysis and survivability in compact electronic, power, and sensing applications.			
(U)				
(U)	CONGRESSIONAL ADD: Corrosion Protection of Aluminum Alloys Used in Aircraft	1.765	1.380	0.000
(U)	In FY 2005: Conducted research to enable, enhance, and exploit environmentally benign cost-effective coating systems for the protection and prevention of corrosion of aluminum alloys used in air and space vehicles.			
(U)	In FY 2006: Continue study of environmentally benign cost-effective coating systems for the protection and prevention of corrosion to aluminum alloys.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	30.465	31.067	32.860

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0602602F, Conventional Munitions.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2304 Mathematics and Computing Sciences	

Cost ($ in Millions)		FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2304	Mathematics and Computing Sciences	25.147	26.802	31.318	30.980	29.612	30.166	30.685	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Mathematics and computing sciences basic research develops novel techniques for mathematical modeling and simulation, algorithm development, complex systems control, and innovative analytical and high performance computing methods for air and space systems. Basic research provides fundamental knowledge enabling improved performance and control of systems and subsystems through accurate models and computational tools, artificial intelligence, and improved programming techniques and theories. The primary areas of research investigated by this project are dynamics and control, physical mathematics and applied analysis, optimization and discreet mathematics, computational mathematics, and electromagnetics.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Perform dynamics and control research to develop innovative techniques for design and analysis of control systems enhancing capabilities and performance of advanced air and space systems.	7.645	8.168	9.655

(U) In FY 2005: Advanced research on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Further developed control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Continued to probe advances in image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Investigated the adaptation of bio-inspired sensing systems, controls, and computational methods.

(U) In FY 2006: Further explore cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Continue examining control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Improve image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Continue to investigate the adaptation of bio-inspired sensing systems, controls, and computational methods.

(U) In FY 2007: Advance techniques for design and analysis of cooperative control systems in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Continue developing control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Continue to advance image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Investigate methods for design and analysis of bio-inspired sensing systems, controls, and computational systems. Develop algorithms for control of and over dynamic, large-scale networks.

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2304 Mathematics and Computing Sciences**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)				
(U)	MAJOR THRUST: Research physical mathematics, applied analysis, and electromagnetics.	8.157	8.746	10.161
(U)	In FY 2005: Continued research to develop models of physical phenomena to improve simulations and device predictability. Investigated methods to advance target location, recognition and identification, and tracking. Probed the properties of coherently propagating ultra-short laser pulses through the atmosphere. Evaluated algorithms of nonlinear optical effects within fiber lasers and nonlinear optical media. Studied the dynamics of transonic/supersonic/hypersonic platforms and warhead reconfiguration through micro-detonation.			
(U)	In FY 2006: Develop more accurate models of physical phenomena to enhance the fidelity of simulations. Investigate properties of coherently propagating ultra-short laser pulses through the atmosphere. Develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media. Study the dynamics of transonic/supersonic/hypersonic platforms. Study the design of reconfigurable warheads through suitable placement and of micro-detonators. Improve methods for recognizing and tracking targets and for penetrating coverings or other dispersive media that obscure targets.			
(U)	In FY 2007: Continue to develop enhanced models of physical phenomena to advance the fidelity of simulations. Further investigate properties of coherently propagating ultra-short laser pulses through the atmosphere. Continue to develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media. Continue to investigate the dynamics of transonic/supersonic/hypersonic platforms. Further study the design of reconfigurable warheads through suitable placement of micro-detonators. Continue to improve methods for recognizing and tracking targets and for penetrating coverings or other dispersive media that obscure targets.			
(U)				
(U)	MAJOR THRUST: Conduct research in optimization, as well as computational and discrete mathematics to validate and further advance mathematical methods, algorithms, and modeling and simulation to solve problems and improve designs of advanced Air Force systems.	9.345	9.888	11.502
(U)	In FY 2005: Elucidated complex problems in system diagnostics/prognostics, air mobility contingencies, and strategic/tactical planning for battlespace information management. Designed modeling techniques and algorithms for various present day and longer term challenges. Integrated new multi-disciplinary design optimization strategies with high-order, time-accurate solutions for superior design of jet engines, directed energy devices, munitions and penetrators, air and space components, and system health and maintenance systems. Continued computing the simulation uncertainty in non-linear models of aerodynamic flows and structural failure predictions.			
(U)	In FY 2006: Continue to solve complex problems in system diagnostics/prognostics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Develop innovative methods and algorithms that will improve modeling and simulation capabilities. Continue to integrate new multi-disciplinary			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2304 Mathematics and Computing Sciences**

(U) B. Accomplishments/Planned Program ($ in Millions)

		FY 2005	FY 2006	FY 2007
(U)	design optimization strategies with high-order, time-accurate solutions for superior design of jet engines, directed energy devices, munitions and penetrators, air and space components, and system health and maintenance systems. Develop mathematical method for solving large or complex problems in logistics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Continue computing the simulation uncertainty in non-linear models of aerodynamic flows and structural failure predictions.			
(U)	In FY 2007: Continue to elucidate complex problems in system diagnostics/prognostics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Continue to develop innovative methods and algorithms that will improve modeling and simulation capabilities. Continue to integrate new multi-disciplinary design optimization strategies with high-order, time-accurate solutions for superior design of jet engines, directed energy devices, munitions and penetrators, air and space components, and system health and maintenance systems. Continue to develop mathematical method for solving large or complex problems in logistics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Continue to enhance uncertainty analysis in non-linear models of aerodynamic flows and structural failure predictions.			
(U)	Total Cost	25.147	26.802	31.318

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602201F, Aerospace Flight Dynamics.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602602F, Conventional Munitions.									
(U) PE 0602702F, Command, Control, and Communications.									
(U) PE 0603789F, C3I Advanced									

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2304 Mathematics and Computing Sciences**

(U) C. Other Program Funding Summary ($ in Millions)

Development.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2305 Electronics

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2305 Electronics	25.646	30.360	33.835	33.163	36.606	37.258	37.855	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Electronics basic research enhances the fundamental understanding of electronic materials, devices, and systems to advance Air Force operational capabilities in directed energy weapons, stealth technologies, electronic countermeasures, information and signal processing, and communications. This research enables the development of electronic processes to model and predict the performance of electronic materials, devices, and systems for power generation, optical signal processing, radiation effects, and high-speed signal processing. The goals are to firmly control the complexity and reliability of electronic systems, increase data transmission and information processing speeds, and to improve the security and reliability of electronic information. The primary areas of research investigated by this project are space electronics; semiconductor materials; optoelectronic information processing and memory; and quantum electronic solids.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Assess military space platform unique electronic circuits to increase their reliability, survivability, and functionality while simultaneously reducing component cost, size, and weight in order to improve spacelift, battlefield awareness and control, mission flexibility, and ease of augmentation and upgrade.	6.488	6.534	7.827
(U) In FY 2005: Further investigated effects of intense radio frequency (RF) pulses on electronic circuits and systems. Continued designing, fabricating, and evaluating wide bandgap semiconductor materials to achieve a unique combination of high RFpower output, high efficiency, low noise, robustness, and radiation hardness. Researched scientific barriers to electronic component miniaturization, nano-propulsion and power, smart skins, radiation hardening, and quantum effect electronics. Completed specific Air Force-National Aeronautics and Space Administration (NASA) nano-satellite projects.			
(U) In FY 2006: Conclude major effort to understand RF pulse effects on electronic circuits. Launch new university center of excellence on radiation effects on electronic materials and devices. Transition the results from basic research efforts to baseline gallium nitride bulk material. Closely review and re-vector, where necessary, the new university nanosatellites projects.			
(U) In FY 2007: Investigate novel materials for reconfigurable electronics produced from major review of entire program. Conclude research efforts on wide bandgap gallium nitride materials and devices and transition to major Defense Advanced Research Projects Agency (DARPA) program. Link university nanosatellite projects to key DoD and commercial space interests, and more aggressively seek space launches for the best nanosatellite projects.			
(U)			
(U) MAJOR THRUST: Investigate quantum and optoelectronic materials and devices, memory, and information processing, as well as nano-science for wide-field spectral sensors and critical, high-speed communication systems in order to achieve communications and spectral dominance of the battlespace to include surveillance, target tracking,	13.123	12.770	15.022

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2305 Electronics

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
and target signature identification.			
(U) In FY 2005: Explored unique nonlinear optical and laser materials and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Explored new concepts, improved efficiencies, and reduced cooling requirements of lasers and detector electronics. Explored ultracompact micro- and nano-photonic structures, chip-scale optical networks, and enhanced data storage (e.g., optoelectronic memory). Probed robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Investigated communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments.			
(U) In FY 2006: Investigate nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Explore nanoelectronics, nanophotonics, and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency lasers wavelength-diverse, high sensitivity detectors. Study advanced optical memory technologies for enhanced data storage. Continue to probe robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Continue to investigate communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments.			
(U) In FY 2007: Further investigate nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Continue to explore nanoelectronics, nanophotonics, and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency lasers wavelength-diverse, high sensitivity detectors. Further the examination of advanced optical memory technologies for enhanced data storage. Investigate technologies for robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Continue to investigate communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments.			
(U)			
(U) MAJOR THRUST: Exploit advances in nanotechnology to support multi-spectral detection technology and chip-scale optical networks. Note: This effort has been broken out from other areas to reflect the increased emphasis being placed on nanotechnology in support of future military capabilities.	0.000	4.000	5.281
(U) In FY 2005: Not Applicable.			
(U) In FY 2006: Explore techniques to control growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Develop guided wave and free space optoelectronic device technology and methods for their integration to enable chip-scale optical networks that will overcome interconnect problems for military platform networks due to future high-speed information processors. Explore nanophotonic			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2305 Electronics**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	concepts for information processing components and systems.			
(U)	In FY 2007: Develop techniques to control growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Continue developing nanoelectronics and nanophotonics for guided wave and free space optoelectronic device technology and method for their integration to enable chip-scale optical networks that will overcome future interconnect problems. Continue exploring nanophotonic concepts for information processing components and systems.			
(U)				
(U)	MAJOR THRUST: Investigate quantum electronic solids phenomena to explore superconducting, magnetic, negative index and nanoscopic materials to produce superconducting tapes for compact power generators and magnets, and for advanced sensors, communications, lightweight antennas, signal processing and ultra-dense memory.	5.056	5.282	5.705
(U)	In FY 2005: Continued examining superconducting quantum computing systems and encryption techniques. Examined methodologies to fabricate high current, high-temperature superconducting cables for enhanced power generation and storage devices. Continued the development of high-temperature magnetic materials with sufficient mechanical strength for use in aircraft electrical systems.			
(U)	In FY 2006: Further examine superconducting quantum computing systems and encryption techniques. Continue to examine methodologies to fabricate high current, high-temperature superconducting materials for enhanced power generation and storage devices. Continue to develop high-temperature magnetic materials for power devices, switches, and bearings in aircraft electrical systems.			
(U)	In FY 2007: Exploit methodologies to fabricate new high current, high-temperature superconducting materials for enhanced power generation and storage devices. Continue search for high-temperature superconductors. Continue to develop high-temperature magnetic materials for power devices, switches, and bearings in aircraft electrical systems. Continue search for three-dimensional negative index materials in the infrared and visible regions, and use these materials to make circuit elements with smaller size and increased functionality.			
(U)				
(U)	CONGRESSIONAL ADD: Quantum Gate	0.979	0.000	0.000
(U)	In FY 2005: Conducted basic research in quantum information technology.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Nanophotonic Components	0.000	1.774	0.000
(U)	In FY 2005: Not Applicable.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2305 Electronics

(U) B. Accomplishments/Planned Program ($ in Millions)

	FY 2005	FY 2006	FY 2007
(U) In FY 2006: Conduct Congressionally-directed effort for nanophotonic components utilized in electronic materials in a number of aircraft, ship, and soldier systems.			
(U) In FY 2007: Not Applicable.			
(U) Total Cost	25.646	30.360	33.835

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602204F, Aerospace Sensors.									
(U) PE 0602702F, Command, Control, and Communications.									
(U) PE 0603203F, Advanced Aerospace Sensors.									
(U) PE 0603789F, C3I Advanced Development.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2306 Materials

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2306 Materials	17.850	17.753	20.302	20.007	20.418	20.774	21.102	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Materials basic research enhances the performance, cost, and reliability of structural materials to eliminate reliability issues related to high-temperature strength, toughness, fatigue, and environmental conditions. This research expands fundamental knowledge of material properties that leads to the development of novel materials for airframe, turbine engine, and spacecraft structures. The goals of this project are to develop improved materials for air and space vehicles that provide increased structural efficiency and reliability, increase the operating temperature of engine materials, and further increase thrust-to-weight ratio of engines. Basic research emphasis is on refractory alloys, intermetallics, polymer composites, metal and ceramic matrix composites, advanced ceramics, and new material processing methods. The primary areas investigated by this project are ceramics, non-metallic hybrid composites, and metallic materials.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Perform non-metallic, ceramic, and hybrid materials research to identify and to design new materials and composites with very-high (>1400F) and ultra-high (>2500F) temperature applications. Create inorganic matrix composites, functional materials (including adhesives/epoxies), and hybrid carbon materials to increase the strength, application, and life span of air and space structural materials. (Note: Ramp up due to increased efforts in high temperature nanomaterials and multi-functional materials).	6.439	7.789	9.620

(U) In FY 2005: Optimized the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Identified and designed multi-functional ceramic materials to enable structurally enhanced smart systems. Continued research on very-high and ultra-high temperature nonoxide ceramic materials. Examined innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites.

(U) In FY 2006: Continue optimizing the thermal and mechanical stability of oxide composites for aircraft and engine applications. Identify new approaches to designing multi-functional structural ceramics materials to enable structurally enhanced smart systems. Investigate high-temperature resistant and lightweight non-oxide ceramic materials. Conduct research on high temperature polymer matrix composites in terms of their durability in harsh environments and its processibility in fabricating high performance structural components. Develop nanomaterials and nanocomposites that will enable reduced system weight and/or size, increased operational lifetime, and multi-functional performance of load-bearing aerospace structures.

(U) In FY 2007: Continue optimizing the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Exploit new approaches to designing multi-functional structural ceramics materials to enable structurally enhanced smart systems for application in extreme environments. Investigate high-temperature resistant and joining methodologies for lightweight ceramic materials. Further examine innovative concepts for developing

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2306 Materials

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Further develop nanomaterials and nanocomposites that will enable reduced system weight and/or size, increased operational lifetime, and multi-functional performance of load-bearing aerospace structures.			
(U)				
(U)	MAJOR THRUST: Research metallic materials and identify relationships between structure (including microstructure), processing, properties, and performance so as to develop affordable and durable metallic systems for advanced engines and aerospace structural applications.	9.157	9.964	10.682
(U)	In FY 2005: Continued exploring and modeling metal matrix composites, refractory metal alloys, and intermetallics for applications at moderate and very high temperatures. Created advanced alloys for multi-functional space systems. Enhanced and broadened computational models by implementing strategies that reduce new structural material maturity time, assess/validate materials design codes, seek integration with design processes, and minimize costs.			
(U)	In FY 2006: Study lightweight structural materials, refractory metals, intermetallic alloys, amorphous alloys and their composites, and micro-laminated materials for sustainable use in aerospace applications. Develop and verify physics-based, quantitative, predictive models that relate processing, chemistry, and structure with properties and performance of metallic materials.			
(U)	In FY 2007: Continue investigating lightweight structural materials, refractory metals, intermetallic alloys, amorphous alloys and their composites, and micro-laminated materials for sustainable use in aerospace applications. Further develop and verify physics-based, quantitative, predictive models that relate processing, chemistry, and structure with properties and performance of metallic materials.			
(U)				
(U)	CONGRESSIONAL ADD: Nanomaterials Research, Nanomanufacturing for Military Applications	2.254	0.000	0.000
(U)	In FY 2005: Conducted basic research in nanomaterials and nanomanufacturing for potential military application.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	17.850	17.753	20.302

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602201F, Aerospace Flight Dynamics.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2306 Materials**

(U) C. Other Program Funding Summary ($ in Millions)

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602601F, Space Technology.

(U) PE 0603211F, Aerospace Structures.

(U) PE 0708011F, Industrial Preparedness.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2307 Fluid Mechanics	

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2307 Fluid Mechanics	27.618	12.879	12.070	11.698	11.942	12.173	12.384	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Fluid mechanics basic research advances fundamental knowledge, tools, data, concepts, and methods for improving the efficiency, effectiveness, and reliability of air and space vehicles. The goals are to improve theoretical models for aerodynamic prediction and design, as well as to originate flow control concepts and predictive methods used to expand current flight performance boundaries through enhanced understanding of key fluid flow (primarily high-speed air) phenomena. Basic research emphasis is on turbulence prediction and control, unsteady and separated flows, subsonic/supersonic/hypersonic flows, and internal fluid dynamics. The primary approach is to perform fundamental experimental investigations and to formulate advanced computational methods for the simulation and study of complex flows, prediction of real gas effects in high-speed flight, and control and prediction of turbulence in flight vehicles and propulsion systems. Primary areas of research investigated by this project are unsteady aerodynamics, supersonic and hypersonic aerodynamics, turbulence, and rotating and internal flows characteristic of turbomachinery flows.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Investigate and characterize complex phenomena in supersonic, hypersonic, and unsteady flows to enable and optimize the design of air and space vehicles and flight control systems.	4.862	5.040	5.486
(U) In FY 2005: Explored methods to optimize unsteady, vortex-dominated flows and rapid maneuver control on Unmanned Aerial Vehicles (UAVs). Characterized and modeled hypersonic flows to include boundary layer phenomena, engine inlets, and plasma aerodynamics. Modeled aerothermal and local shock phenomena in hypersonic flows, control concepts, and performance optimization.			
(U) In FY 2006: Further explore methods to optimize unsteady, vortex-dominated flows, and rapid maneuver controls on UAVs. Continue to model and validate unsteady hypersonic flow simulation tools to include boundary layer effects, engine inlets, and plasma aerodynamics. Continue to model aerothermal and local shock phenomena in hypersonic flows with emphasis on control concepts and performance optimization. Explore control strategies for mitigating excessive heat transfer and unsteadiness in hypersonic flows and for abating the effects of highly separated flows.			
(U) In FY 2007: Characterize and model critical phenomena required to predict and control unsteady, vortex-dominated flows and to develop rapid maneuver controls on UAVs. Validate current models and explore higher-fidelity models for unsteady aerodynamics of complex, hypersonic flows to include boundary layer effects, shock-dominated flows (engine inlets), and nonequilibrium effects. Develop control strategy models for mitigating excessive heat transfer and unsteadiness in hypersonic flows and for abating the effects of highly separated flows.			
(U)			
(U) MAJOR THRUST: Expand fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts. Study complex rotating and internal flow phenomena related to turbomachinery and jet engine	5.820	5.868	6.584

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2307 Fluid Mechanics

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
applications with an emphasis on flow control approaches.			
(U) In FY 2005: Evaluated advanced flow control coupling mechanisms in turbulent flows. Used large eddy simulation techniques to probe heat transfer and fluid flow coupling. Modeled unsteady flow control inputs on wings and jet engines to include reduced order, closed-loop flow control demonstrations. Explored aerodynamic mistuning mechanisms in multiple blade row interactions tied to high-cycle fatigue failures. Applied control approaches to flow interactions using measurement and actuation devices compatible with harsh environments.			
(U) In FY 2006: Validate studies of advanced flow control coupling mechanisms in complex, turbulent flows. Validate large eddy simulation techniques to probe heat transfer and fluid flow coupling. Continue to model unsteady flow control inputs on wings and jet engines to include reduced order, closed-loop flow control demonstrations. Further explore and develop models for aerodynamic mistuning mechanisms in multiple blade row interactions tied to high cycle fatigue failures. Further develop control approaches for flow interactions using flow control measurement and actuation devices for harsh environments.			
(U) In FY 2007: Further evaluate advanced flow control coupling mechanisms in complex, turbulent flows, including transient phenomena and time accurate simulation techniques. Evaluate reduced order, closed-loop flow control mechanisms on unsteady flow of complex geometries and jet engines. Further develop large eddy simulation techniques to include heat transfer and fluid flow coupling in preliminary simulations of film cooling flows. Evaluate hybrid computational techniques for accurately modeling turbulent flows. Evaluate coupling between aerodynamic and structural mistuning mechanisms in multiple blade row interactions tied to high cycle fatigue failures. Develop predictive tools for unsteady flow control approaches using sensors and actuators for harsh environments.			
(U)			
(U) CONGRESSIONAL ADD: National Hypersonic Research Center	1.959	1.971	0.000
(U) In FY 2005: Conducted fundamental scientific and engineering research studies at the National Hypersonics Research Center.			
(U) In FY 2006: Expand basic hypersonics research and develop a strong academic program in hypersonics flow physics.			
(U) In FY 2007: Not Applicable.			
(U)			
(U) CONGRESSIONAL ADD: National Aerospace Leadership Initiative	14.977	0.000	0.000
(U) In FY 2005: Established a broad based agenda to reinvigorate America's aerospace research and development and maintain America's competitive leadership in aviation.			
(U) In FY 2006: Not Applicable.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**

(U) B. Accomplishments/Planned Program ($ in Millions)

	FY 2005	FY 2006	FY 2007
(U) In FY 2007: Not Applicable.			
(U) Total Cost	27.618	12.879	12.070

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602201F, Aerospace Flight Dynamics.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0603211F, Aerospace Structures.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2308 Propulsion

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2308 Propulsion	16.524	21.729	18.347	18.058	18.477	18.821	19.140	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Propulsion basic research expounds fundamental knowledge to enable and enhance efficient utilization of energy in airbreathing engines, chemical and non-chemical rockets, and combined cycle propulsion systems for future rapid global reach and on-demand space access. Basic research thrusts include airbreathing propulsion, space power and propulsion, high altitude signature characterization and contamination, propulsion diagnostics, thermal management of space-based power and propulsion, and the synthesis of new chemical propellants. These thrusts can be grouped into reacting flows and non-chemical energetics. Study of reacting flows involves the complex coupling between energy release through chemical reaction and the flow processes that transport chemical reactants, products, and energy. Non-chemical energetics research includes both plasma and beamed-energy propulsion for orbit raising space missions and ultra-high energy techniques for space-based energy utilization. Primary areas of research investigated by this project are space power, propulsion, combustion, and diagnostics.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Research and model space propulsion and power in the areas of chemistry, electronics, miniaturization, and contamination/signature.	7.823	8.358	9.121
(U) In FY 2005: Expanded studies in plasma-based, charged droplet-based, and beamed-energy thrusters. Explored new engine concepts such as pulsed detonation rocket engines. Evaluated unsteady flow coupling and plasma ignition combustion efficiencies and stability. Investigated high altitude signature characterization and spacecraft cross-contamination. Examined Magnetohydrodynamics (MHD) flow control to optimize scramjet flow path performance. Investigated lightweight superconducting magnet capability for MHD flow control of advanced engines.			
(U) In FY 2006: Continue studies in plasma-based, charged droplet-based, and beamed-energy thrusters. Continue studies of pulsed detonation rocket engines and other new engine concepts. Evaluate methods to predict and suppress combustion instabilities. Investigate high altitude plumes signature and contamination. Examine MHD flow control to optimize scramjet flow path performance. Continue to investigate lightweight superconducting magnet capability for MHD flow control of advanced engines.			
(U) In FY 2007: Continue studies in plasma-based, charged droplet-based, and beamed-energy thrusters. Continue to investigate pulsed detonation rocket engines and other new engine concepts. Continue to examine methods to predict and suppress combustion instabilities. Continue to investigate high altitude plumes signature and contamination. Continue to investigate MHD flow control to optimize scramjet flow path performance. Continue to investigate lightweight superconducting magnet capability for MHD flow control of advanced engines.			
(U)			
(U) MAJOR THRUST: Explore combustion, propulsion, and diagnostics in subsonics, supersonics, and hypersonics.	7.722	8.443	9.226

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2308 Propulsion**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	Investigate multi-phase, turbulent reacting flows to improve the performance of propulsion systems, including gas turbines, ramjets, scramjets, pulsed detonation engines, and rockets.			
(U)	In FY 2005: Improved laser diagnostic measurement capabilities in the characterization of reacting flows. Probed molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions. Incorporated prediction methodologies, which are both quantitatively accurate and computationally tractable, into turbulent combustion models. Enhanced scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Identified and evaluated fuels and propellants that are more energetic, environmentally benign, and less sensitive to accidental detonations.			
(U)	In FY 2006: Continue improving laser diagnostic measurement capabilities in the characterization of turbulent reacting flows. Probe deeper into molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions. Further incorporate prediction methodologies, which are both quantitatively accurate and computationally tractable, into turbulent combustion models. Enhance scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Continue to investigate fuels and propellants that are more energetic, environmentally benign, and less sensitive to accidental detonations.			
(U)	In FY 2007: Continue improving laser diagnostic measurement capabilities in the characterization of turbulent reacting flows. Continue to investigate molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions. Further incorporate prediction methodologies, which are both quantitatively accurate and computationally tractable, into turbulent combustion models. Further enhance scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Continue to investigate fuels and propellants that are more energetic, environmentally benign, and less sensitive to accidental detonations. Formulate strategies for using alternate hydrocarbon fuels based on the incorporation of detailed chemistry models into large eddy simulations.			
(U)				
(U)	CONGRESSIONAL ADD: Coal-Based Fuel	0.979	4.928	0.000
(U)	In FY 2005: Researched the production of coal-based jet fuels in increasingly larger quantities through refinery trials. Evaluated refinery-produced fuels for large-scale combustion and thermal stability for use in advanced high-performance engines.			
(U)	In FY 2006: Continue the efforts between the Energy Institute of Penn State and the United States Air Force (USAF) to enhance thermal stability for use in advanced high-performance engines. (Note: In FY 2005, this Add was called Coal-Derived Jet Fuels)			
(U)	In FY 2007: Not Applicable.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2308 Propulsion**

(U) B. Accomplishments/Planned Program ($ in Millions)

	FY 2005	FY 2006	FY 2007
(U) Total Cost	16.524	21.729	18.347

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0603211F, Aerospace Structures.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2311 Space and Information Sciences	

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2311 Space and Information Sciences	29.553	30.488	27.005	25.489	25.368	25.829	26.255	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Space and information sciences basic research provides fundamental understanding of the space environment for optimum design of Air Force systems operating in near-Earth orbit, geosynchronous orbit, and deep space. The goal is to enable greater, more cost-affordable, protection of space assets from space debris, solar wind, solar flares, cosmic rays, and geomagnetic storms. Focus is on specifying the flow of mass, momentum, and energy through space to develop a global model that connects solar activity with the deposition of energy at the Earth. Methods are developed to forecast the turbulent plasma phenomena that mediate the flow of energy through space in order to enhance the effectiveness of Air Force global dominance through space operations. The primary areas of research investigated by the space environment portion of this program are solar phenomena and weather, magnetospheric and ionospheric effects, space debris studies, and innovative space-based communications. The primary research areas in the information sciences portion of this program are complex systems and algorithms, communications and signal processing, information operations, and information fusion.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Research space environment to improve solar plasma theories and modeling in the areas of solar phenomena, space weather, magneto/ionosphere effects, space debris, adaptive optics for improved space observation, better space-based communications, and the quantifying of risks to space systems.	8.363	8.553	9.234

(U) In FY 2005: Exploited astronomical detection, tracking, and cataloging algorithms for enhanced protection of DoD surveillance capability in conjunction with data from the Communications/Navigation Outage Forecasting System-Solar Mass Ejection Imager (C/NOFS-SMEI) satellites. Supported development of ground-based advanced technology solar telescope adaptive optics systems, light detection and ranging radars, nanotechnology, and advanced signal-processing algorithms. Refined forecasting of ionosphere and space environment effects. Exploited developments in all-sky imaging and multi-conjugate adaptive optics to obtain infrared observations of ionospheric plasma physics, gravity waves, dynamics, optical clutter, and small, dim, deep space targets. Continued investigating solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity.

(U) In FY 2006: Explore advanced modeling algorithms to take advantage of increased computer power and speed. Seek improved plasma models to enhance understanding of basic plasma theory. Seek fundamental processes of energetic particle scattering in the near-Earth environment to lay groundwork for protection of space assets. Continue investigating solar processes and energetic events, the solar wind, and fundamental processes in the magnetosphere, ionosphere, and thermosphere. Seek understanding of fundamental processes controlling space plasma to improve ability to forecast near-Earth space environment. Continue to exploit data from DoD surveillance assets in conjunction with data from C/NOFS-SMEI satellites to improve remote sensing of interplanetary space. Continue developing ground-based optical telescope technologies to include adaptive optics, photon detection,

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2311 Space and Information Sciences

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	spectral resolution, nanotechnology, advanced signal-processing algorithms, and developing space-based sensor technology. Continue to exploit developments in all-sky imaging and multi-conjugate adaptive optics to obtain visible and infrared observations of ionospheric plasma phenomena, optical clutter, and small, dim, deep space targets.			
(U)	In FY 2007: Expand development of ground-based optical telescope technologies (i.e., adaptive optics, photon detection, spectral resolution, nanotechnology, and advanced signal-processing algorithms) to include radio telescopes. Continue developing space-based sensor technology. Explore the solar interior as a complex system through advanced modeling techniques. Continue to explore advanced modeling algorithms to take advantage of increased computer power and speed, and to seek improved plasma models to enhance understanding of basic plasma theory. Develop understanding of fundamental processes of energetic particle scattering in the near Earth environment to support protection of space assets. Continue investigating solar processes and energetic events, the solar wind, and fundamental processes in the magnetosphere, ionosphere, and thermosphere. Seek understanding of fundamental processes controlling space plasma to improve ability to forecast near-Earth space environment. Continue to analyze data from DoD surveillance and the C/NOFS-SMEI satellites to improve remote sensing of interplanetary space. Initiate research to investigate the neutral winds above 150 kilometers. Employ all-sky imaging to study of ionospheric plasma phenomena and develop techniques to quantify these observations.			
(U)				
(U)	MAJOR THRUST: Investigate innovative technologies for space-based communication capabilities to ensure continued Air Force space dominance.	1.000	1.000	1.000
(U)	In FY 2005: Examined innovative methods for optical communications. Probed novel techniques for potential bandwidth efficient modulation to enhance satellite communications. Continued to explore the basic mechanisms of dual polarization antennas for space applications.			
(U)	In FY 2006: Widen consideration of innovative methods for optical communications. Continue to probe novel techniques for potential bandwidth efficient modulation to enhance satellite communications. Continue to explore the basic mechanisms of dual polarization antennas for space applications.			
(U)	In FY 2007: Investigate innovative methods for optical communications such as partial coherence, polarization modulation, and liquid crystal spatial modification techniques. Continue to explore the basic mechanisms of dual polarization antennas for space applications.			
(U)				
(U)	MAJOR THRUST: Investigate signal communications, surveillance, and targeting for increased awareness and improved command and control for the battlefield commander. Efforts include research in linear operator theory, generalized functions and probability, harmonic methods, and asymptotic expansions.	4.211	4.306	4.846

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Space and Information Sciences**

(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2005	FY 2006	FY 2007
(U) In FY 2005: Improved data fusion science to permit rapid data conversion across multiple bands into graphical and conceptualized information. Promoted methodologies to evaluate the performance of new wireless mobile, networked communications systems. Assessed technical alternatives on the overall feasibility of super-resolution millimeter and search and rescue imagery. Solidified the hybrid radio-frequency (RF)/free-space optical paradigm and refined the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. Enabled ultra-wide band transmission of hyperspectral and other diverse data.			
(U) In FY 2006: Further develop data fusion science to enable rapid data conversion across multiple bands into graphical and conceptualized information. Continue to promote methodologies to evaluate the performance of new wireless mobile, networked communications systems. Further assess technical alternatives on the overall feasibility of super-resolution millimeter and search and rescue imagery. Continue to solidify the hybrid RF/free-space optical paradigm and refine the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. Further develop ultra-wide band transmission technology for hyperspectral and other diverse data.			
(U) In FY 2007: Continue exploring data fusion science to enable rapid data conversion across multiple bands into graphical and conceptualized information. Continue to study methodologies for evaluating the performance of new wireless mobile, networked communications systems. Continue study and assessment of technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery. Continue to investigate the hybrid radio-frequency/free-space optical paradigm and refine the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. Continue to develop ultra-wide band transmission technology for hyperspectral and other diverse data.			
(U)			
(U) MAJOR THRUST: Conduct research in complex systems and algorithms for highly flexible, reliable, secure, and rich information systems supporting battlefield commanders using artificial intelligence, information warfare techniques, intelligent agents, knowledge bases, distributed systems, machine learning, uncertainty reasoning, information warfare, and information fusion.	10.590	11.109	11.925
(U) In FY 2005: Continued research in information assurance for protection of future battlespace/infosphere systems and networks. Developed information fusion to provide deep, adaptive, expert decision support. Constructed quantum computer devices and algorithms to allow enhanced tracking, recognition, and characterization to improve awareness and command and control. Designed, implemented, and evaluated quantum-computing architectures for fast, accurate solutions of complex fluid dynamics.			
(U) In FY 2006: Develop information operations science techniques to proactively protect information intensive systems and networks. Further develop information fusion science to provide deep, adaptive, expert decision support. Exploit quantum and bio-computing techniques and algorithms to allow enhanced tracking, recognition, and characterization			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2311 Space and Information Sciences

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	to improve situational awareness, command and control, and security. Begin to investigate first principles of software system architectures.			
(U)	In FY 2007: Continue to develop information operations science techniques to exploit information intensive systems and networks. Further develop information fusion science to provide deep, adaptive, expert decision support. Continue to exploit quantum and bio-computing techniques and algorithms to allow enhanced tracking, recognition, and characterization to improve situational awareness, command and control, and security. Continue to investigate first principles of software system architectures including characteristic property metrics and begin development of automatic software architecture analysis tools.			
(U)				
(U)	CONGRESSIONAL ADD: Chabot Space and Science Center	1.960	0.000	0.000
(U)	In FY 2005: Increased the fundamental understanding of the upper atmosphere, as well as education outreach projects to support space science education programs designed to train the next generation of scientists and engineers.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Griffith Observatory's Planetarium	0.979	0.986	0.000
(U)	In FY 2005: Supported educational programming and exhibits that demonstrate the application of defense technology and research.			
(U)	In FY 2006: Continue to support educational programming and exhibits that demonstrate the application of defense technology and research. (Note: In FY 2005, this Add was called Demonstrating Space Research and Applications).			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Network Information and Space Security Center	2.450	4.534	0.000
(U)	In FY 2005: Conducted fundamental multi-disciplinary scientific research associated with network information and space security efforts.			
(U)	In FY 2006: Continue to conduct fundamental multi-disciplinary scientific research associated with network information and space security efforts to help satisfy critical U.S. Space Command needs.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	29.553	30.488	27.005

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Space and Information Sciences**

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0602702F, Command, Control, and Communications.									
(U) PE 0603410F, Space System Environmental Interactions Technology.									
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2312 Biological Sciences	

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2312 Biological Sciences	9.437	9.687	10.052	10.501	10.774	10.974	11.159	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Biological basic science research provides the fundamental knowledge necessary to understand and enable technologies associated with selected biological responses induced by chemical and physical agents, electromagnetic sensors based on biomimicry, biomolecular materials, biochromatics, and luminescence. The goal is to exploit biological properties to control and manipulate operational environments. Research topics are focused on the interactions of chemicals and physical agents (lasers and microwaves) with human tissues and associated effects to enable safety assessment strategies, hazard-free development and use of future air and space materials and directed energy systems, and innovation of biotechnologies to enhance the physiological performance and protection of Air Force personnel. Research in biomimetic sensors strives to mimic the biological detection systems of organisms at the molecular level in developing novel man-made sensors. Basic research in biocatalysis characterizes and bioengineers cellular enzymes to biosynthesize renewable hydrogen fuel from sunlight and water. Research in biomaterials focuses on the mimicking of natural materials, using organisms as biomaterial factories of new materials, genetically altering existing organisms for new materials capabilities, or taking existing biomaterials/organisms and using them as novel materials like viral gradients or processing them further to make a useful material as in biomineralization. Research in biointerfacial science is focused on new biosensors and bionanotechnology, and specifically addresses the fundamental science at either the biotic-biotic or the biotic-abiotic interface.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Characterize, understand, predict, control, and engineer biomolecular responses induced in organisms by chemical and physical agents of Air Force significance, such as alternate jet fuels, nano-energetic materials, and directed energy. Identify, characterize, and engineer novel enzymatic properties that enable photosynthetic microbes to use light energy for the renewable generation of hydrogen fuel from water. Explore biomolecular profiles and mechanisms involved in the stimulatory rather than inhibitory biological responses induced by low-doses of toxic agents.	5.459	5.493	5.746

(U) In FY 2005: Modeled risks associated with exposure to fuels and complex mixtures. Analyzed the biokinetics and biodistribution of JP-8 jet fuel components. Continued exploring, profiling, and modeling bio-informatics methodologies. Characterized, parameterized, and codified enzymes, proteins, biocatalysts, and bio-energetic agents to enable and enhance efficiencies in the synthesis and processing of future air and space materials.

(U) In FY 2006: Refine biokinetics models used to predict the fuel constituent levels in tissues following dermal and pulmonary exposures to fuel mixtures. Continue developing and begin applying methodologies for profiling and modeling the biomolecular responses induced by the interactions of directed energy and nano-energetic materials with biological systems. Begin developing and utilizing biocatalysis techniques for use in genetically engineering photosynthetic microbes to generate fuel-cell hydrogen from water. Begin exploring the dose ranges and kinetics associated with the positive stimulatory or "hormetic" responses of biological systems exposed to very low-levels of

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2312 Biological Sciences**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	known toxic substances and hazardous radiation.			
(U)	In FY 2007: Experimentally validate biokinetics models used to predict the fuel constituent levels in tissues following dermal and pulmonary exposures to fuel mixtures. Continue profiling and modeling the biomolecular responses induced by the interactions of directed energy and nano-energetic materials with biological systems. Continue utilizing biocatalysis techniques and genetic engineering principles to elicit the water-based generation of fuel-cell hydrogen by photosynthetic microbes. Investigate the biomolecular profiles for underlying mechanisms associated with positive stimulatory or "hormetic" responses of biological systems exposed to very low-levels of known toxic substances and hazardous radiation.			
(U)				
(U)	MAJOR THRUST: Explore biomimetics, biomaterials, and biointerfacial sciences to enable development of novel sensors, engineering processes, and mechanisms, and the synthesis of novel materials, as well as to research new sensor modalities, explore surface-mediated process, and delve into extreme environmental conditions.	3.978	4.194	4.306
(U)	In FY 2005: Investigated, evaluated, and modeled natural occurrences, processes, and designs for future applications in infrared devices. Explored biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Exploited biomaterial and biointerfacial sciences to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications.			
(U)	In FY 2006: Investigate, evaluate, model, and mimic biological processes and designs for future applications in near ambient temperature sensing devices. Probe and manipulate biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Continue to exploit biomaterial and biointerfacial sciences to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications.			
(U)	In FY 2007: Phase out investigating, evaluating, modeling, and mimicking biological processes and designs for future applications in near ambient temperature sensing devices, and add predator avoidance and new prey detection schemes as future technology areas. Further probe and manipulate biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Continue to exploit biomaterial and biointerfacial sciences to control cellular systems to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications. Research surface mediated cellular differentiation as a new sensor modality. Expand into extremophile research to access biosynthetic pathways not achievable with room temperature organisms.			
(U)	Total Cost	9.437	9.687	10.052

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2312 Biological Sciences

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602202F, Human Effectiveness Applied Research.									
(U) PE 0602204F, Aerospace Sensors.									
(U) PE 0602602F, Conventional Munitions.									
(U) PE 0602702F, Command, Control, and Communication.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2006

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2313 Human Performance

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2313 Human Performance	13.183	13.687	10.804	10.650	14.725	15.014	15.281	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Human performance basic research provides the fundamental knowledge necessary to examine and exploit all aspects of human information processing critical to Air Force operations. The goal is to develop useful quantitative models of the way Air Force warfighters perceive, appraise, and manipulate their environment; make decisions in complex tasks under stress or uncertainty; and adapt to extreme sensory, biophysical, or cognitive workloads. Sensory research emphasizes visual, auditory, equilibrium, and kinesthetic systems and their optimal integration. Basic research topics focus investigations on developing Air Force technologies including specialized interactive displays, simulators, intelligent control systems, sensors and fused-image displays, and adaptive systems for operator and team training. Novel strategies to maintain decisive awareness by preventing impaired operating performance due to jet lag, shift work, night operations, and the loss of life and/or aircraft due to stress, inattention, or lack of vigilance are being evaluated. The primary areas of research investigated by this project are sensory systems; cognition, perception, and chronobiology; and behavioral and physiological measures of fatigue.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Probe human sensory systems and perceptions critical for warfighter performance (auditory and visual processes, multi-sensory integration, and sensory biomimetics) to enhance human-machine interaction in Air Force weapon systems. Research biophysical and neural mechanisms to determine human cognitive performance under conditions of sleep loss, sustained operations, and non-standard sleep/wake duty cycles.	4.763	5.079	5.445

(U) In FY 2005: Conducted empirical research with mathematical and/or computational modeling in spatial audition, speech perception, and hearing protection. Assessed multi-sensory integration methods and novel biological sensing mechanisms. Probed biophysical mechanisms responsible for fatigue. Evaluated models of sleep/wake dynamics to predict specific deficits in warfighter performance.

(U) In FY 2006: Continue to conduct empirical research with mathematical and computational modeling in spatial audition, speech perception, and hearing protection. Further assess multi-sensory integration methods and novel biological sensing mechanisms. Continue to probe biophysical mechanisms responsible for fatigue. Evaluate models of sleep/wake dynamics to predict specific consequences in the performance of an individual warfighter. Study the effects of ultrashort laser pulse on the eye (laser flash blindness).

(U) In FY 2007: Continue empirical research with mathematical and computational modeling in spatial audition, speech perception, and hearing protection. Exploit multi-sensory integration methods and novel biological sensing mechanisms. Continue to probe biophysical mechanisms responsible for fatigue. Further evaluate models of sleep/wake dynamics to predict specific consequences in the performance of an individual warfighter. Continue to investigate the effects of ultrashort laser pulse on the eye (laser flash blindness).

(U)

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2313 Human Performance

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	MAJOR THRUST: Evaluate cognition and perception research to measure and analyze dimensions of human performance in complex, multi-interaction command and control tasks. Investigate behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss.	5.620	5.158	5.359
(U)	In FY 2005: Analyzed models of enhanced human performance aided or augmented by intelligent systems. Assessed mechanisms affecting training effectiveness for operator and team performance. Continued modeling relationships between individual skill differences and interactions with envisioned training. Explored measures to avert/mitigate human error in conditions of information overload and fatigue.			
(U)	In FY 2006: Develop quantitative models and methods for improved understanding of individual and team information processing and decision making. Assess mechanisms affecting training effectiveness for individuals and teams. Continue modeling relationships between individual skill differences and interactions with envisioned training. Continue to explore measures to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload.			
(U)	In FY 2007: Refine quantitative models of individual and team information processing and decision-making including applications to systems to improve the speed and accuracy of networked teams. Employ progress on modeling individual and team training for the development of training systems optimized for specific individuals, teams, and applications. Assess mechanisms for continuous learning and automated, diagnostic mentoring of individuals. Develop models of symbolic spatial-imaginal processing. Continue exploring measures to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload.			
(U)				
(U)	CONGRESSIONAL ADD: Virtual Operation for Unmanned Aerial Vehicles	2.800	3.450	0.000
(U)	In FY 2005: Conducted research to design, develop, implement, and test the hardware, software, and aeronautical systems necessary to create immersive ground control stations based on virtual reality technology.			
(U)	In FY 2006: Support university research team that is designing, developing, implementing, and testing the hardware, software, and aeronautical systems necessary to create immersive ground control stations based on virtual reality technology.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	13.183	13.687	10.804

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602202F, Human									

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2313 Human Performance**

(U) C. Other Program Funding Summary ($ in Millions)

Effectiveness Applied Research.

(U) PE 0602702F, Command, Control, and Communication.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 4113 External Research Programs Interface	

Cost ($ in Millions)		FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
4113	External Research Programs Interface	12.281	7.687	8.696	9.045	18.446	18.815	19.157	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

The primary elements in this project are to facilitate interactions between the international and domestic research communities and Air Force researchers, and to support and develop scientists and engineers with an awareness of Air Force basic research priorities. These professional interactions and collaborations stimulate scientific and engineering education beneficial to the Air Force, increase the awareness of Air Force basic research priorities to the research community as a whole, and attract talented scientists and engineers to address Air Force needs. International interactions facilitate future interoperability of coalition systems and foster relationships with future coalition partners. This project also seeks to enhance educational interactions with historically black colleges and universities, Hispanic serving institutions, and other minority institutions.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Foster international science and technology cooperation by supporting the Air Force's international strategy mission. Identify and obtain unique foreign research capabilities through the international technology liaison missions of the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development.	3.903	4.004	4.520

(U) In FY 2005: Provided centralized cooperation expertise, supported international technology liaison missions, and identified unique research capabilities of high interest to the U.S. Air Force. Supported international visits of high-level DoD delegations and provided primary interface to coordinate international participation among DoD organizations. Aided in Air Force fiscal commitments to foreign NATO-affiliated research institutes.

(U) In FY 2006: Provide centralized cooperation expertise and support international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Capitalize on foreign investments by influencing and acquiring world-class scientific research. Establish and maintain access to technical briefs and publications on unique foreign research and research capabilities. Support international visits of high-level DoD delegations and provide primary interface to coordinate international participation among DoD organizations. Aid in Air Force fiscal commitments to foreign NATO-affiliated research institutes.

(U) In FY 2007: Continue to provide centralized cooperation expertise and support international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Continue to capitalize on foreign investments by influencing and acquiring world-class scientific research. Continue to seek and maintain access to technical briefs and publications on unique foreign research and research capabilities. Continue to support international visits of high-level DoD delegations and provide primary interface to coordinate international participation among DoD organizations. Continue to assist in Air Force fiscal commitments to foreign

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 4113 External Research Programs Interface

(U) B. Accomplishments/Planned Program ($ in Millions)

		FY 2005	FY 2006	FY 2007
	NATO-affiliated research institutes.			
(U)				
(U)	MAJOR THRUST: Strengthen science, mathematics, and engineering research and educational infrastructure in the U.S., thereby strengthening Air Force technical capabilities. Assure the Air Force of continuing availability of superior technical talent and forge Air Force Research Laboratory relationships with premiere scientists.	3.577	3.683	4.176
(U)	In FY 2005: Continued to support scientist and engineering research programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Enhanced awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research.			
(U)	In FY 2006: Continue to support scientist and engineering research programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Enhance awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research.			
(U)	In FY 2007: Continue to support science, mathematics, and engineering research and educational outreach programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Increase awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research.			
(U)				
(U)	CONGRESSIONAL ADD: Minority LEADERS	4.801	0.000	0.000
(U)	In FY 2005: Conducted research in the areas of both materials and aerospace sensors.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	12.281	7.687	8.696

(U) C. Other Program Funding Summary ($ in Millions)

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0601103D, University Research Initiative.									
(U) PE 0602102F, Materials.									

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BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **4113 External Research Programs Interface**

(U) C. Other Program Funding Summary ($ in Millions)

(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602204F, Aerospace Avionics.
(U) PE 0602269F, Hypersonic Technology Program.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702F, Command, Control and Communication.

(U) D. Acquisition Strategy

Not Applicable.