PE NUMBER: 0601102F
PE TITLE: Defense Research Sciences

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2005

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

	Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	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	210.206	252.113	223.894	245.595	235.963	252.810	257.004	262.005	Continuing	TBD
2301	Physics	25.952	26.009	23.788	27.134	24.377	24.543	24.821	26.414	Continuing	TBD
2302	Solid Mechanics and Structures	11.461	13.159	14.343	16.859	15.446	15.709	16.063	16.388	Continuing	TBD
2303	Chemistry	27.508	30.818	30.116	31.654	29.115	29.115	29.219	29.190	Continuing	TBD
2304	Mathematics and Computing Sciences	28.837	25.437	27.190	30.856	30.509	29.143	29.698	30.203	Continuing	TBD
2305	Electronics	24.654	25.943	28.999	33.367	32.662	36.033	36.686	37.268	Continuing	TBD
2306	Materials	14.803	18.057	18.010	20.017	19.705	20.099	20.456	20.774	Continuing	TBD
2307	Fluid Mechanics	12.676	33.603	11.066	11.901	11.521	11.754	11.985	12.191	Continuing	TBD
2308	Propulsion	15.418	16.715	17.043	18.064	17.783	18.184	18.528	18.839	Continuing	TBD
2311	Space and Information Sciences	20.064	29.895	25.329	26.645	25.107	24.973	25.433	25.849	Continuing	TBD
2312	Biological Sciences	9.130	9.546	9.827	9.886	10.342	10.604	10.803	10.983	Continuing	TBD
2313	Human Performance	12.471	10.503	10.385	10.641	10.488	14.494	14.784	15.044	Continuing	TBD
4113	External Research Programs Interface	7.232	12.428	7.798	8.571	8.908	18.159	18.528	18.862	Continuing	TBD

Note: In FY 2005, Project 2311, "Space Sciences," changed its name to "Space and Information Sciences."

(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 2005, Congress added $2.1 million for Microwave Vacuum Electronic Power Research Initiative, $0.5 million for Non-Lethal Stunning/Immobilizing Weapons, $1.8 million for Corrosion Protection of Aluminum Alloys used in Aircraft, $1.0 million for Quantum Gate, $2.3 million for Nanomaterials Research, Nanomanufacturing for Military Applications, $21.0 million for National Aerospace Leadership Initiative (transferred from PE 0603211F), $2.0 million for National Hypersonic Research Center, $1.0 million for J-P Coal Based Jet Fuel (transferred from PE 0603789F), $2.0 million for Chabot Space and Science Center, $1.0 million for Demonstrating Space Research and Applications, $2.5 million for Network, Information, and Space Security, and $4.9 million for Minority Leaders (transferred from PE 0602204F). 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.

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

		FY 2004	FY 2005	FY 2006	FY 2007
(U)	Previous President's Budget	212.897	217.304	230.536	256.246
(U)	Current PBR/President's Budget	210.206	252.113	223.894	245.595
(U)	Total Adjustments	-2.691	34.809		
(U)	Congressional Program Reductions		-5.050		
	Congressional Rescissions		-2.241		
	Congressional Increases		42.100		
	Reprogrammings	0.600			
	SBIR/STTR Transfer	-3.291			

(U) Significant Program Changes:

Not Applicable.

C. Performance Metrics

(U) Under Development.

Exhibit R-2a, RDT&E Project Justification

DATE: **February 2005**

BUDGET ACTIVITY: **01 Basic Research**

PE NUMBER AND TITLE: **0601102F Defense Research Sciences**

PROJECT NUMBER AND TITLE: **2301 Physics**

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2301 Physics	25.952	26.009	23.788	27.134	24.377	24.543	24.821	26.414	Continuing	TBD
Quantity of RDT&E Articles	0	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 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and multi-aperture adaptive optics.	10.119	8.223	8.317	9.357

(U) In FY 2004: Expanded studies of high power fiber lasers, in particular those using novel material combinations, which support large-core, single-mode fibers. Investigated direct and nonlinear optical methods for combining beams of fiber lasers to achieve power levels needed for multiple directed energy applications. Researched converting wavelengths of high-power laser arrays to values needed for space applications and aircraft protection. Expanded studies of large, lightweight adaptive optics and large aperture telescopes for very high-resolution space surveillance and imaging applications. Extended studies of large aperture adaptive telescopes for very high-resolution deep space imaging. Studied new optical techniques to achieve very large aperture, very wide-band phased array radars in space. Studied laser micro-machining techniques for producing specialized micro- and nano-components for multi-functional micro- and nano-satellites.

(U) In FY 2005: Continue investigating physical properties of lasers to enable, monitor, and regulate tunable, wide wavelength band lasers (e.g., solid state, free electron, fiber). Investigate novel tomographic and optical techniques tied to large, multi-aperture, adaptive telescopes and radars. Expand studies of novel laser micro-and nano-machining techniques and their applications to new materials with desirable space and electronic properties. Explore 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.

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(U)	In FY 2007: Further investigate novel 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 microelectronics and micromechanics fabrication and packaging capabilities. Continue to explore laser applications for infrared countermeasures.				
(U)					
(U)	MAJOR THRUST: Explore high-energy electro-energetic devices, communication systems, surveillance and countermeasure platforms, and aerodynamic systems to facilitate creation of better propellants and more capable directed energy weapons. Note: In FY 2005, these efforts were moved to the "atoms, molecules, and particles" Major Thrust in this Project.	8.232	0.000	0.000	0.000
(U)	In FY 2004: Enhanced research studies in plasma physics to investigate fundamental interactions between charged particles and electromagnetic fields for all-electric military platforms, high-bandwidth communications, advanced long-distance covert surveillance, and space communications and surveillance. Expanded research into the physics of molecular interactions in combustion and high energy density propellants. Examined the detailed physics of material, surface, and air breakdown in the presence of strong electric fields to facilitate creation of more compact, lighter weight, portable pulsed power systems in order to power future directed energy weapons. Expanded the understanding of short-pulse intense electric fields' effects on cells and organelles.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(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. Note: In FY 2005, the "high-energy electro-energetics" efforts described earlier in this Project were moved to this Major Thrust.	1.276	11.164	11.332	13.120
(U)	In FY 2004: Expanded investigations into the fundamental interplay between atoms and strong electromagnetic fields to identify potentially new classes of lasers. Continued measuring ultraviolet emission cross-sections from electron impact. Explored uses for laser-cooled and trapped atoms.				
(U)	In FY 2005: Continue to characterize interactions of atoms and molecules in strong electromagnetic fields for laser applications. Examine techniques for precision measurement of atomic and molecular properties, atomic collision processes, and fundamental interactions between atoms, molecules, ions, and				

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
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radiation. Explore advances in high-resolution spectroscopy via the trapping and cooling of atoms and ions. Continue exploring dynamic molecular interactions in combustion and high energy density propellants. Continue examining materials, surfaces, and air breakdown in the presence of strong electric and sub-meter wave fields. Continue plasma physics studies in the areas of all-electric military platforms, high-bandwidth communications, and advanced long-distance covert surveillance. Continue 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 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. Continue to explore the use of electron beam generated microwave for high-bandwidth communications, advanced long-distance covert surveillance, electronic countermeasures, and directed energy weapons. Investigate ultra-high current density cathode concepts. 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.	3.200	4.045	4.139	4.657

(U) In FY 2004: Conducted research on the interaction of systems and sensors with atmospheric and space environments. Developed models to predict the atmospheric effects on laser propagation. Investigated

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	means to expand models of sensor performance to incorporate measurements of terrestrial and space backgrounds and radiation. Examined methods of using holographic techniques for dynamic correction of distortion and aberration in space surveillance telescopes. Studied methods to enhance hyperspectral imagery using polarization and hypertemporal information.				
(U)	In FY 2005: Probe effects of atmospheric and space environments on sensors and energy (i.e., information) propagation. Identify, characterize, and model parameters enabling remote sensing, locating, and precision tracking of objects in and from space. Evaluate tools and enhance 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 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)					
(U)	CONGRESSIONAL ADD: Center for Astronomical Active Optics.	0.977	0.000	0.000	0.000
(U)	In FY 2004: Studied optional methods and techniques that may be used to produce larger telescope based on ongoing adaptive optic accomplishments.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: National Fotonics Research Center.	1.660	0.000	0.000	0.000
(U)	In FY 2004: Supported fundamental research at the National Photonics Research Center.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Non-lethal Stunning/Immobilizing Weapons Research.	0.488	0.495	0.000	0.000
(U)	In FY 2004: Conducted fundamental scientific investigations in non-lethal stunning and immobilizing weapons research.				
(U)	In FY 2005: Continue accelerated efforts in conducting fundamental scientific investigations in				

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non-lethal stunning and immobilizing weapons research.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(U) CONGRESSIONAL ADD: Microwave Vacuum Electronics Power Research Initiative	0.000	2.082	0.000	0.000

(U) In FY 2004: Not Applicable.

(U) In FY 2005: Re-establish 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) Total Cost	25.952	26.009	23.788	27.134

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

	FY 2004 Actual	FY 2005 Estimate	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 2005
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 2004 Actual	FY 2005 Estimate	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	11.461	13.159	14.343	16.859	15.446	15.709	16.063	16.388	Continuing	TBD
Quantity of RDT&E Articles	0	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. Note: In FY 2005, efforts described later in this Project were moved to this Major Thrust.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2004	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. Note: In FY 2005, efforts described later in this Project were moved to this Major Thrust.	2.370	6.240	7.088	7.957

(U) In FY 2004: Enhanced research in the mechanics of advanced materials and devices to accelerate their use as composites, high-temperature alloys, and ceramic matrix composites. Applied multi-functional mechanics with nonlinear behavior to enhance design of multi-functional materials and structures. Developed methods to combine multi-scale modeling and information technology to design new materials and structures. Examined the foundations of nano-mechanics in transitioning between continuum mechanics and atomistic modeling.

(U) In FY 2005: Advance 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. Search for methods to combine information technology and multi-scale modeling in the design of new materials and structures. Continue 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 multifunctional aerospace material systems and devices and to predict their performance and structural integrity. Develop and

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BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2302 Solid Mechanics and Structures**

exploit methods that combine information technology and modeling in the design of new material systems and devices at multiple scales.

(U) In FY 2007: 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. 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. Continue developing and exploiting methods that combine information technology and modeling in the design of new material systems and devices at multiple scales

(U)

(U) MAJOR THRUST: Analyze and model structural fatigue and loss of integrity to mitigate their detrimental impact to Air Force weapon systems. Note: In FY 2005, these efforts were moved to the "structural fatigue and mechanics" Major Thrust in this Project.	4.921	0.000	0.000	0.000

(U) In FY 2004: Investigated the structural and material aspects of high-cycle metal fatigue and other aging mechanisms. Explored metal fatigue-generation caused by the vibration of compressor and turbine blades. Expanded and enhanced fundamental computer simulations to predict structural response to assorted stimuli. Explored material science research to identify and mitigate material degeneration and degradation. Developed novel system techniques to analyze vehicle integrity.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(U) MAJOR THRUST: Conduct structural mechanics research to examine innovative adaptive structure concepts to improve the design and performance of air and space systems to include multi-mission unmanned aerial vehicles (UAVs). Note: In FY 2005, these efforts were moved to the "structural fatigue and mechanics" Major Thrust in this Project.	4.170	0.000	0.000	0.000

(U) In FY 2004: Expanded models to predict the interaction between structural motion and high-speed aerodynamics characteristic of UAVs. Further probed the behavior of distributed sensor and actuator systems of aircraft. Explored the mechanical and dynamic behavior of micro- and nano-scale structures to achieve exceptional capabilities in micro-electro-mechanical systems and nano-electro-mechanical systems.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

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(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 UAVs.	0.000	6.919	7.255	8.902
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Continue to examine and analyze structural mechanics to include fatigue, integrity, high cycle metal fatigue, and other material aging phenomena. Investigate metal fatigue-generation caused by the vibration of compressors and turbine blades. Continue assessing means and models to identify, evaluate, and mitigate material degeneration and degradation. Continue developing novel system techniques to analyze vehicle integrity. Advance models of interaction between UAV structural motion and high-speed aerodynamics. Characterize distributed sensor and actuator systems. Explore the mechanical and dynamic behavior of micro/nano-scale structures. Note: Prior to FY 2005, these efforts were covered under other activities in this Project.				
(U)	In FY 2006: Explore methods for constructing and modeling morphing structures that broaden system operating 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, for novel structural applications.				
(U)	In FY 2007: Continue to explore novel methods for constructing and modeling morphing structures that broaden system operating capabilities. Continue development of 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. Continue development of structural health monitoring techniques and systems and exploration of mechanical and dynamic behavior of micro/nano-scale structures. Continue exploration of exploitation of nonlinear phenomena, such as structural deformation and aero-elastic effects, for novel structural applications.				
(U)	Total Cost	11.461	13.159	14.343	16.859

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

	FY 2004 Actual	FY 2005 Estimate	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.										

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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 0602201F, Aerospace Flight Dynamics.

(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 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2303 Chemistry	

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2303 Chemistry	27.508	30.818	30.116	31.654	29.115	29.115	29.219	29.190	Continuing	TBD
Quantity of RDT&E Articles	0	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 the effects of chemical and morphological structures on functional and mechanical properties of polymeric materials 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; and surface and interfacial science.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2004	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.	11.468	13.264	13.418	14.347

(U) In FY 2004: Completed modeling efforts of the chemical interactions between air and space systems and the space environment. Explored uses of ion and plasma chemistry for combustion control applications. Investigate concepts of reactive energetic nano-structures for safer penetrating munitions and enhanced spacecraft payload fractions. Developed and validated theoretical methods to predict and design the behavior and properties of nano-structures. Probed novel chemical theories, syntheses, detection techniques, and modeling and simulation focused on fuels and rocket propellants that are more energetic, environmentally benign, and emit reduced signatures and are less sensitive to accidental detonations. Studied the fundamental behavior of new fuels in hydrocarbon-fueled scramjets and combined-cycle engines. Enhanced models of chemically reacting flows associated with hypersonic vehicles. Researched new chemical sources of electronic excited states needed to fuel chemical laser systems. Optimized properties of potential fuels to increase the mass of space payloads and satellite lifetimes.

(U) In FY 2005: Explore ion and plasma chemistry for combustion control applications. Investigate nano-structure concepts and models for propulsion and munition reactive energetics. Continue modeling chemically reacting flows associated with hypersonic vehicles, hydrocarbon-fueled scramjets, and combined-cycle engines. Continue to optimize chemical properties enriching high energy lasers,

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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 nanoscale 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, and to develop new high-energy, high density chemicals for propellants and propulsion systems, 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 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. Continue efforts to develop higher performance, less sensitive nanoscale energetic materials 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.	9.137	8.737	9.637	9.988

(U) In FY 2004: Developed organic molecules with high optical nonlinearities for protection against laser threats. Explored flexible structures that can provide functions such as sensing, power generation and storage, electronics, and electronic memory for integration into multi-functional structures. Enhance electro-optic polymers for improved performance for photonic radar development. Researched organic-based electronics for multi-functional integration.

(U) In FY 2005: Design and characterize conductive polymers, photonic polymers, nano-structures, and bio-inspired polymers. Evaluate nano-composite structures and mechanical properties for potential applications under harsh space environments. Focus 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. 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

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
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	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.	5.926	7.032	7.061	7.319
(U)	In FY 2004: Improved theoretical and predictive methods for surface and interfacial chemical processes. Explored the chemical and physical properties of novel lubricants. Assembled novel multi-functional coatings for the corrosion protection of aging aircraft. Developed low-friction, long-life, multi-functional surface structures and coatings. Probed nano-scale surface structures with enhanced energy densities for better weapon system energy storage and delivery. Studied chemically directed self-assembly to produce novel three-dimensional surface nano-structures for sensor, optical, and power applications.				
(U)	In FY 2005: Enhance theoretical and predictive methods for surface and interfacial chemical processes. Create and characterize novel multi-functional surface structures, coatings, covers, and lubricants. Investigate nano-scale surface structures for enhanced energy-density storage/delivery and chemically-directed self-assembled surfaces for sensor, optical, and power applications. Probe 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 surface interact with their environment at the interface. Continue to 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)					
(U)	CONGRESSIONAL ADD: Corrosion Protection of Aluminum Alloys Used in Aircraft.	0.977	1.785	0.000	0.000
(U)	In FY 2004: Advanced fundamental scientific research to enable, enhance, and exploit corrosion				

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protection of aluminum alloys used in air and space vehicles.

(U) In FY 2005: Conduct 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: Not Applicable.

(U) In FY 2007: Not Applicable.

(U) Total Cost	27.508	30.818	30.116	31.654

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

	FY 2004 Actual	FY 2005 Estimate	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 2005
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 2004 Actual	FY 2005 Estimate	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	28.837	25.437	27.190	30.856	30.509	29.143	29.698	30.203	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: In FY 2005, some activities in this project will be moved to the Project 2311 in this Program Element.

(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 2004	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.	6.387	7.735	8.256	9.543

(U) In FY 2004: Researched cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Developed control methodology to improve non-equilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion, materials processing, and agile autonomous flight. Explored advances in image processing and sensors applicable to advanced UAV controllers, smart munitions, and non-destructive vehicle testing. Enhanced designs of computational models to analyze natural processes for adaptation to air and space systems. Adapted explorations in bio-inspired sensing systems to assess feasibility for and applicability in use in controlling autonomous systems.

(U) In FY 2005: Advance research on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Further develop control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Continue to probe advances in image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Investigate 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

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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. Refine 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.

(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. Note: In FY 2005, these efforts were moved to Project 2311 in this Program Element.	2.465	0.000	0.000	0.000

(U) In FY 2004: Investigated expanding the capability of critical mobile, networked communications through mathematical innovations in signal processing. Explored hybrid radio frequency and optical phenomenology to achieve robust wireless communication. Further delineated the domain of applicability of self-learning and heuristic methods such as super-resolution imaging. Examined the fundamental principles of stochastic and probabilistic analysis to actuate proof-of-concept surveillance/reconnaissance and targeting systems. Examined revolutionary technologies that attain ultra-fast, reliable information exchange. Employed linear operator theory, generalized functions, differential equations, and quantum theory to facilitate flexible, high bandwidth reliable transmission of multi-source data.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(U) MAJOR THRUST: Conduct research in complex systems and algorithms for highly flexible, reliable, and rich information systems supporting battlefield commanders using artificial intelligence, information warfare, intelligent agents, knowledge bases, distributed systems, machine learning, uncertainty	6.164	0.000	0.000	0.000

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reasoning, intelligence/information assurance, and information fusion. Note: In FY 2005, these efforts were moved to Project 2311 in this Program Element.

(U) In FY 2004: Researched information assurance, including support for language-based security, mobile code security, protected execution, steganography/steganalysis, dynamic, and adaptive intrusion detection for protection of future battlespace/infosphere systems and networks. Further developed computational techniques/software for information fusion at the situation refinement and impact assessment levels to provide decision support. Constructed quantum computer devices that enable atomic level computing a million times faster than a state-of-the-art silicon chip to allow enhanced target tracking, command and control, and decisive awareness. Designed, implemented, and tested quantum computing algorithms and architectures enabling fast, accurate solutions of complex fluid dynamics problems eliminating the need for multiple design iterations and prototype testing. Developed scalable quantum computers for automatic target recognition and target characterization.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(U)	MAJOR THRUST: Research physical mathematics, applied analysis, and electromagnetics.	6.119	8.257	8.846	10.011

(U) In FY 2004: Researched developing accurate models of physical phenomena that enhance the fidelity of simulations and predictability of devices. Further investigated the properties of coherently propagating ultra-short laser pulses through the air and their exploitation in areas such as electronic warfare, laser-guided munitions, and irradiation of chemical/biological clouds. Developed algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media. Completed formulating optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluated novel methods to penetrate tree cover with wide band radar to recognize and track targets. Studied the feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators. Enhanced description of the dynamics of internal stores released from transonic/supersonic platforms.

(U) In FY 2005: Continue research to develop models of physical phenomena to improve simulations and device predictability. Investigate methods to advance target location, recognition and identification, and tracking. Probe the properties of coherently propagating ultra-short laser pulses through the atmosphere. Evaluate algorithms of nonlinear optical effects within fiber lasers and nonlinear optical media. Study 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 simulations.

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	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 reconfiguration 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 more accurate models of physical phenomena to enhance the fidelity simulations. Continue to 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. Study the dynamics of transonic/supersonic/hypersonic platforms. Further study the design reconfigurable warheads reconfiguration through suitable placement and 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: Investigate optimization and discrete mathematics to validate and further advance mathematical methods, algorithms, and models. Note: In FY 2005, these efforts were moved to the "computational and discrete mathematics research" Major Thrust in this Project.	4.314	0.000	0.000	0.000
(U)	In FY 2004: Enhanced research for solving complex problems in system diagnostics/prognostics, air mobility contingencies, and strategic/tactical planning for battlespace information management. Further evaluated anytime algorithms -- those that produce a feasible, but not necessarily optimal, solution. Examined new modeling techniques and algorithms for various Air Force current and long-term challenges, such as target allocation for unmanned air vehicles, special operations planning, and system health and maintenance.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Perform computational mathematics research to develop unique modeling and simulation capabilities to improve designs of advanced Air Force systems. Note: In FY 2005, these efforts were moved to the "computational and discrete mathematics research" Major Thrusts in this Project.	3.388	0.000	0.000	0.000
(U)	In FY 2004: Initiated the integration of new multi-disciplinary design optimization strategies with high-order, time-accurate solvers for superior design of jet engines, aircraft wings, munitions, as well as other air and space components. Developed algorithms for unsteady reactive flow, munitions penetration				

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and fragmentation, and plasma dynamics for directed energy weapons. Computed the simulation uncertainty in nonlinear models of aerodynamic flows and structural failure predictions.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(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.	0.000	9.445	10.088	11.302

(U) In FY 2004: Not Applicable.

(U) In FY 2005: Solve complex problems in system diagnostics/prognostics, air mobility contingencies, and strategic/tactical planning for battlespace information management. Design modeling techniques and algorithms for various present day and longer term challenges. 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 computing the simulation uncertainty in non-linear models of aerodynamic flows and structural failure predictions. Note: Prior to FY 2005, these activities were covered under other efforts earlier in this Project.

(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 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 solve 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

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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) Total Cost	28.837	25.437	27.190	30.856	

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

	FY 2004 Actual	FY 2005 Estimate	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 Development.										

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

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BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2305 Electronics

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2305 Electronics	24.654	25.943	28.999	33.367	32.662	36.033	36.686	37.268	Continuing	TBD
Quantity of RDT&E Articles	0	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 2004	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.	8.295	6.573	6.647	7.727

(U) In FY 2004: Probed intense radio frequency (RF) pulse effects on electronic circuits and systems. Designed, fabricated, and evaluated wide bandgap semiconductor materials to achieve a unique combination of high RF power output, high efficiency, low noise, robustness, and radiation hardness. Evaluated efforts to identify electronic approaches to increasing spacecraft survivability. Enhanced research on the interaction of systems and sensors with the space environment. Developed models to predict the effect of terrestrial and space backgrounds and radiation on sensor performance in order to promote secure, wide bandwidth communication through the atmosphere and ionosphere, as well as between satellites. Explored design and potential applications of small satellites (1kg to 100 kg) for rapid access to space and flexible mission capabilities. Researched scientific barriers to component miniaturization, nano-propulsion and power, smart skins, radiation hardening, and quantum effect electronics. Supported joint Air Force-NASA university nano-satellite projects with emphasis on space industry partnerships.

(U) In FY 2005: Further investigate effects of intense RF pulses on electronic circuits and systems. Continue designing, fabricating, and evaluating wide bandgap semiconductor materials to achieve a unique combination of RF power output, high efficiency, low noise, robustness, and radiation hardness. Research scientific barriers to electronic component miniaturization, nano-propulsion and power, smart skins, radiation hardening, and quantum effect electronics. Complete specific Air Force-NASA

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	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: Launch major new initiative in materials and devices for reconfigurable electronics. Conclude research efforts on wide bandgap gallium nitride materials and devices. Link university nanosatellite projects to key DoD and commercial space interests. Organize and conduct a major review on progress and plans toward reconfigurable electronics.				
(U)					
(U)	MAJOR THRUST: Conduct semiconductor materials research for detection and emission of optical radiation from the far infrared to ultraviolet range to achieve spectral dominance of the battlespace including surveillance, target tracking, and target signature identification. Note: In FY 2005, these efforts were moved to the "quantum and optoelectronic materials" Major Thrust in this Project.	7.460	0.000	0.000	0.000
(U)	In FY 2004: Pursued nonlinear optical materials to protect critical optical systems from laser radiation. Synthesized laser materials to degrade or disable an adversary's detection and tracking capabilities. Enhanced nano-fabrication technology for unique optoelectronic materials. Assessed basic electronic mechanisms to improve the efficiency and reduce the cooling requirements of lasers and detectors. Evaluated fast multi-band detectors for battlespace characterization. Identified new materials for high efficiency photovoltaic devices, room temperature ferromagnets, and compact, high-power semiconductor lasers.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Conduct research in optoelectronic information processing and nano-science to explore the design, development, and application of novel optoelectronic materials and devices to enhance critical communication system accuracy and speed. Note: In FY 2005, these efforts were moved to the "quantum and optoelectronic materials" Major Thrust in this Project.	2.248	0.000	0.000	0.000
(U)	In FY 2004: Explored ultracompact, micro-photonic, and nano-photonic structures and chip scale optical networks. Expanded investigations of robust monolithic and miniature tetrahertz frequency devices for security, remote sensing, optical communications, and optical signal processing. Initiated terahertz quantum cascade laser research.				
(U)	In FY 2005: Not Applicable.				

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(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Examine optoelectronic memory and persistent spectral hole-burning approaches for enhanced data storage and processing to enable superior strategic awareness. Note: In FY 2005, these efforts were moved to the "quantum and optoelectronic materials" Major Thrust in this Project.	1.503	0.000	0.000	0.000
(U)	In FY 2004: Investigated methods for constructing page-oriented or holographic memory configurations in two- or three-dimensions. Explored methods of buffering, storing, and retrieving data at rates and quantities anticipated for multi-spectral devices. Investigated techniques for enhancing capabilities in high-speed image capture, data storage, and information processing for surveillance, target discrimination, and autonomous navigation.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(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, and target signature identification. Note: Prior to FY 2005, these activities were covered under other Major Thrusts in this Project.	0.000	13.323	13.070	14.722
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Explore unique nonlinear optical and laser materials and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Explore new concepts, improve efficiencies, and reduce cooling requirements of lasers and detector electronics. Explore ultracompact micro- and nano-photonic structures, chip-scale optical networks, and enhanced data storage (e.g., optoelectronic memory). Probe robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Investigate 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				

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	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. Further explore nanoelectronics, nanophotonics, and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency lasers wavelength-diverse, high sensitivity detectors. Continue to study 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	0.000	4.000	5.281
(U)	In FY 2004: Not Applicable.				
(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 concepts for information processing components and systems.				
(U)	In FY 2007: Further explore 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.				
(U)					
(U)	MAJOR THRUST: Investigate quantum electronic solids phenomena to explore superconducting, magnetic, and nanoscopic materials to produce superconducting tapes for compact power generators and magnets, and for advanced sensing, communications, and signal processing and ultra-dense memory.	3.781	5.056	5.282	5.637
(U)	In FY 2004: Examined superconducting quantum systems for adaptation to quantum computing and				

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	encryption. Conducted research on improving high-current, high-temperature superconducting cables and tapes for enhanced power generation and storage on directed energy weapons and space platforms. Furthered the development of new high-temperature magnetic materials with sufficient mechanical strength for use in aircraft with higher electric workloads.				
(U)	In FY 2005: Continue examining superconducting quantum computing systems and encryption techniques. Examine methodologies to fabricate high current, high-temperature superconducting cables for enhanced power generation and storage devices. Continue 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: Further examine superconducting quantum computing systems and encryption techniques. Exploit 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)					
(U)	CONGRESSIONAL ADD: Thin Film Magnetic Materials.	1.367	0.000	0.000	0.000
(U)	In FY 2004: Studied the fundamental scientific phenomena associated with thin film magnetic materials.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Quantum Gate (SASC Title was "Advanced Research in Quantum Info Tech").	0.000	0.991	0.000	0.000
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Conduct basic research in quantum information technology. This research is similar to that conducted with a FY 2004 Congressional add reflected in Project 2311 of this Program Element.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)	Total Cost	24.654	25.943	28.999	33.367

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2305 Electronics**

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

	FY 2004 Actual	FY 2005 Estimate	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 2005**

BUDGET ACTIVITY: **01 Basic Research**

PE NUMBER AND TITLE: **0601102F Defense Research Sciences**

PROJECT NUMBER AND TITLE: **2306 Materials**

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2306 Materials	14.803	18.057	18.010	20.017	19.705	20.099	20.456	20.774	Continuing	TBD
Quantity of RDT&E Articles	0	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 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Identify ceramic and non-metallic materials for use in developing new materials and composites for very-high (>1400F) and ultra-high (>2500F) temperature applications. Note: In FY 2005, all non-metallic efforts were combined into a single Major Thrust later in this Project.	4.915	0.000	0.000	0.000
(U) In FY 2004: Optimized the thermal and mechanical stability of oxide composites for aircraft and jet engine blade applications. Extended research on ultra-high temperature ceramic materials for space propulsion and structural systems. Researched the design and optimization of multi-functional ceramic materials to enable structurally enhanced smart systems.				
(U) In FY 2005: Not Applicable.				
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Not Applicable.				
(U)				
(U) MAJOR THRUST: Investigate organic matrix composites and hybrid materials (including adhesives/epoxies) that can be used to increase the strength and life span of air and space structural materials. Note: In FY 2005, all non-metallic efforts were combined into a single Major Thrust later in this Project.	2.235	0.000	0.000	0.000
(U) In FY 2004: Further probed the effects of cyclic thermal loads down to cryogenic temperatures on polymer matrix composites in order to increase durability in liquid fuel tank materials. Researched into fiber sizing techniques in glass fiber reinforced structures to minimize the degradation of mechanical and electromagnetic properties due to moisture.				
(U) In FY 2005: Not Applicable.				
(U) In FY 2006: Not Applicable.				

Exhibit R-2a, RDT&E Project Justification			DATE: February 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2306 Materials	

(U)	In FY 2007: Not Applicable.				
(U)					
(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: Prior to FY 2005, these efforts were covered under other Major Thrusts earlier in this Project.	0.000	6.439	7.889	9.535
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Optimize the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Identify and design multi-functional ceramic materials to enable structurally enhanced smart systems. Continue research on very-high and ultra-high temperature nonoxide ceramic materials. Examine 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. 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, 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. Continue to investigate high-temperature resistant and lightweight nonoxide ceramic materials. Further examine innovative concepts for developing 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, 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.	7.653	9.338	10.121	10.482

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2306 Materials**

(U) In FY 2004: Expanded experimental and modeling studies of mechanical strength, thermal stability, performance prediction, and lifetime assessment of composites, refractory metal alloys, and intermetallics for applications at moderate and very high temperatures. Developed advanced alloys for multi-functional space systems. Explored scientific bases for computational design to reduce new material experimentation development costs. Developed new models to reduce new material maturity time and to minimize associated costs. Developed high performance materials more affordably by integrating material development and engineering system design.

(U) In FY 2005: Continue exploring and modeling metal matrix composites, refractory metal alloys, and intermetallics for applications at moderate and very high temperatures. Create advanced alloys for multi-functional space systems. Enhance and broaden 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 studying 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.	0.000	2.280	0.000	0.000

(U) In FY 2004: Not Applicable.

(U) In FY 2005: Conduct 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	14.803	18.057	18.010	20.017

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

	FY 2004 Actual	FY 2005 Estimate	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.

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
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 0602201F, Aerospace Flight Dynamics.

(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 2005**

BUDGET ACTIVITY: **01 Basic Research**

PE NUMBER AND TITLE: **0601102F Defense Research Sciences**

PROJECT NUMBER AND TITLE: **2307 Fluid Mechanics**

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	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	12.676	33.603	11.066	11.901	11.521	11.754	11.985	12.191	Continuing	TBD
Quantity of RDT&E Articles	0	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 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Characterize the critical phenomena in unsteady aerodynamic flows and expand fundamental knowledge of high-speed airflows to optimize air vehicle designs that will revolutionize future weapon systems. Note: In FY 2005, these efforts moved to the "supersonic, hypersonic, unsteady aerodynamics" Major Thrust later in this Project	2.690	0.000	0.000	0.000
(U) In FY 2004: Developed numerical tools and validated the experimental database to determine the effect of unsteady, vortex-dominated flows on the control and flight performance of UAVs. Investigated aero/structure interactions associated with rapid maneuver UAVs. Evaluated tools for the accurate prediction of highly separated flow over complex air vehicle and weapon systems.				
(U) In FY 2005: Not Applicable..				
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Not Applicable.				
(U)				
(U) MAJOR THRUST: Investigate complex phenomena in supersonic and hypersonic flows to enable the design of future Air Force trans-atmospheric vehicles and flight control systems. Note: In FY 2005, these efforts moved to the "supersonic, hypersonic, unsteady aerodynamics" Major Thrust later in this Project.	3.094	0.000	0.000	0.000
(U) In FY 2004: Examined advanced flow control concepts for shock-dominated flows. Pursued aerothermal numerical simulation capabilities to quantify heat transfer and unsteadiness for flight vehicles.				

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**	

(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(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. Note: Prior to FY 2005, these efforts were covered under other Major Thrusts earlier in this Project.	0.000	4.862	5.040	5.417
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Explore methods to optimize unsteady, vortex-dominated flows and rapid maneuver control on UAVs. Characterize and model hypersonic flows to include boundary layer phenomena, engine inlets, and plasma aerodynamics. Model 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: Exploit methods to optimize unsteady, vortex-dominated flows, and rapid maneuver controls on UAVs. Validate and refine models for unsteady aerodynamics of complex, hypersonic flows to include boundary layer effects, engine inlets, and plasma aerodynamics. Continue to model aerothermal and local shock phenomena in hypersonic flows, control concepts, and performance optimization. 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: Explore fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts to enhance the performance, controllability, and stability in air vehicles. Note: In FY 2005, these efforts moved to the "turbulence and rotating flows" Major Thrust later in this Project.	2.750	0.000	0.000	0.000
(U)	In FY 2004: Developed approaches for modeling unsteady flow control inputs on aircraft wings and jet engines. Utilized reduced order models for turbulent flow control applications and affordable engineering predictive models for the air vehicle design process. Evaluated promising flow control actuation concepts on realistic geometries in wind tunnel tests. Furthered investigations into flow control-coupling mechanisms in turbulent flows to enable agile flight vehicles.				

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**	

(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Study complex rotating and internal flows characteristic of turbomachinery and jet engine applications. Note: In FY 2005, these efforts moved to the "turbulence and rotating flows" Major Thrust later in this Project	2.190	0.000	0.000	0.000
(U)	In FY 2004: Explored coupling mechanisms in multiple blade row interactions in order to develop understanding of forcing modes in turbomachinery and to predict high cycle fatigue failures in jet engines. Used large eddy simulation techniques to explore heat transfer and fluid flow coupling in turbine engine flow fields. Investigated detailed flow interactions using flow control measurement and actuation devices for use in harsh environments.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(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 applications, with an emphasis on flow control approaches. Note: Prior to FY 2005, these efforts were covered under other Major Thrusts earlier in this Project.	0.000	5.944	6.026	6.484
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Evaluate advanced flow control coupling mechanisms in turbulent flows. Use large eddy simulation techniques to probe heat transfer and fluid flow coupling. Model unsteady flow control inputs on wings and jet engines to include reduced order, closed-loop flow control demonstrations. Explore aerodynamic mistuning mechanisms in multiple blade row interactions tied to high cycle fatigue failures. Apply 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.				

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**

(U)	In FY 2007: Further evaluate validation studies of advanced flow control coupling mechanisms in complex, turbulent flows, including transient phenomena and time accurate simulation techniques. Further develop large eddy simulation techniques to include heat transfer and fluid flow coupling in preliminary simulations of film cooling flows. Develop predictive tools for unsteady flow control inputs on wings and jet engines. Evaluate coupling between aerodynamic and structural mistuning mechanisms in multiple blade row interactions tied to high cycle fatigue failures. Develop predictive tools for flow control in harsh environments.				
(U)					
(U)	CONGRESSIONAL ADD: National Hypersonic Research Center.	1.952	1.982	0.000	0.000
(U)	In FY 2004: Conduct fundamental scientific and engineering research studies at the National Hypersonics Research Center.				
(U)	In FY 2005: Conduct fundamental scientific and engineering research studies at the National Hypersonics Research Center.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: National Aerospace Leadership Initiative.	0.000	20.815	0.000	0.000
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Establish 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.				
(U)	In FY 2007: Not Applicable.				
(U)	Total Cost	12.676	33.603	11.066	11.901

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

	FY 2004 Actual	FY 2005 Estimate	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										

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2307 Fluid Mechanics

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

Structures.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: **February 2005**

BUDGET ACTIVITY: **01 Basic Research**

PE NUMBER AND TITLE: **0601102F Defense Research Sciences**

PROJECT NUMBER AND TITLE: **2308 Propulsion**

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
2308 Propulsion	15.418	16.715	17.043	18.064	17.783	18.184	18.528	18.839	Continuing	TBD
Quantity of RDT&E Articles	0	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 2004	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. Note: In FY 2005, the plasma efforts in this Major Thrust moved to the "combustion, propulsion, and diagnostics" Major Thrust in this Project.	6.577	7.923	8.478	8.988

(U) In FY 2004: Studied micro-chemical, plasma-based, and beamed-energy based thrusters to improve thrust, specific impulse, and control of propulsion systems for high-precision constellations of cooperating micro-satellites in order to enhance decisive awareness of threats and opportunities. Furthered research into new engine concepts such as pulsed detonation engines, hybrid rockets, and combined cycle engines. Advanced supercritical combustion models and leverage computational capabilities that will enhance the design of new hydrocarbon, cryogenic, and monopropellant-fueled engines. Completed research of plasma turbulence and its effects on the transport coefficients in order to develop a new class of more versatile plasma thrusters. Researched high altitude signature characterization and spacecraft cross-contamination, especially in the presence of multiple thrusters and satellites. Examined magnetohydrodynamic (MHD) flow control to optimize propulsion system flow path performance in scramjets. Investigated lightweight super conducting magnet capability for onboard flight-rated systems needed to achieve MHD flow control of advanced engines. Investigated plasma ignition approaches to improve combustion efficiency and stability in scramjets and high altitude subsonic airbreathing propulsion systems.

(U) In FY 2005: Expand studies in plasma-based, charged droplet-based, and beamed-energy thrusters. Explore new engine concepts such as pulsed detonation rocket engines. Evaluate unsteady flow coupling and plasma ignition combustion efficiencies and stability. Investigate high altitude signature

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2308 Propulsion**	

	characterization and spacecraft cross-contamination. Examine MHD flow control to optimize scramjet flow path performance. Investigate 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 studying pulsed detonation rocket engines and other new engine concepts. Evaluate methods to predict and suppress combustion instabilities. Continue to investigate high altitude plumes signature and contamination. Further 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)					
(U)	MAJOR THRUST: Explore combustion, propulsion, and diagnostics in subsonics, supersonics, and hypersonics. Investigate multi-phase, turbulent reacting flows to improve the performance of propulsion systems, including gas turbines, ramjets, scramjets, pulsed detonation engines, and rockets.	6.352	7.801	8.565	9.076
(U)	In FY 2004: Improved laser diagnostic measurement capabilities with expanded agility over limited wavelength ranges for time-resolved characterization of reacting flows. Developed detailed mechanisms for hydrocarbon fuel combustion at elevated pressures. Explored scientific basis for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies.				
(U)	In FY 2005: Improve laser diagnostic measurement capabilities in the characterization of reacting flows. Probe molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions. 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. Identify and evaluate 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				

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2308 Propulsion**

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 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. 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.

(U)

(U) CONGRESSIONAL ADD: Coal-derived Jet Fuels.	2.489	0.991	0.000	0.000

(U) In FY 2004: Researched producing coal-based jet fuels in increasingly larger quantities through refinery trials. Evaluated refinery-produced fuels for large-scale combustion and thermal stability.

(U) In FY 2005: Research to produce coal-based jet fuels in increasingly larger quantities through refinery trials. Evaluate refinery-produced fuels for large-scale combustion and thermal stability for use in advanced high-performance engines.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U) Total Cost	15.418	16.715	17.043	18.064

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

	FY 2004 Actual	FY 2005 Estimate	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										

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2308 Propulsion**

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

Structures.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2005

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 2004 Actual	FY 2005 Estimate	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	20.064	29.895	25.329	26.645	25.107	24.973	25.433	25.849	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0	0		

Note: In FY 2005, the Project name, "Space Sciences," changed to "Space and Information Sciences." Additionally, in FY 2005, some activities in Project 2304 of this Program Element will be moved to this Project.

(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 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Analyze solar physics and weather to develop techniques for improved space observations and protection of Air Force space assets and operations. Note: In FY 2005, these efforts were moved to "Space Environment Research" Major Thrust later in this Project.	3.554	0.000	0.000	0.000
(U) In FY 2004: Exploited solar physics models to develop techniques for protecting assets against high-energy plasma ejections. Supported cutting-edge instrumentation development for ground-based solar telescopes. Investigated solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity through support of ground-based optical and radio solar observatories, as well as university and government teams managing space-based instruments. Defined best practices and commonalities of algorithms used to model and simulate the space environment, focused on plug-and-play capability within next-generation computational architectures.				
(U) In FY 2005: Not Applicable.				
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Not Applicable.				
(U)				
(U) MAJOR THRUST: Research magnetosphere and ionosphere effects to enhance global surveillance, geolocation, and communication. Note: In FY 2005, these efforts were moved to "Space Environment Research" Major Thrust later in this Project.	3.554	0.000	0.000	0.000

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Space and Information Sciences**	

(U)	In FY 2004: Expanded deployment of research sensors to observe ionospheric scintillation and worldwide plasma turbulence radio disruptions. Supported scientific analyses of space-based and ground-based data assimilation techniques to modernize ionospheric and space weather forecasting. Designed and examined observational equipment globally to improve capability to observe atmospheric gravity wave interactions with radars, advance electro-optical instrumentation, and light detection and ranging techniques. Exploited cutting-edge developments in all-sky imaging optics to obtain sensitive infrared observations of ionospheric plasma physics, gravity waves, dynamics, and optical clutter.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Research, characterize, and model space debris to protect Air Force space assets. Note: In FY 2005, these efforts were moved to the "Space Environment Research" Major Thrust later in this Project.	4.261	0.000	0.000	0.000
(U)	In FY 2004: Cataloged and tracked the populations of Near Space/Earth Objects and space debris particles derived from comets and asteroids. Advanced multi-conjugate adaptive optics for unparalleled resolution of small, dim, deep space targets. Furthered developments in astronomical detection and tracking algorithms to enhance space awareness and control capabilities. Expanded development of future space radar surveillance systems using nanotechnology and advanced signal processing algorithms.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	MAJOR THRUST: Expand theories for the development of physics-based modeling, improved space observations through advancements in multi-conjugate adaptive optics, and the quantifying of risks to Air Force systems. Note: In FY 2005, these efforts were moved to "Space Environment Research" Major Thrust later in this Project.	2.932	0.000	0.000	0.000
(U)	In FY 2004: Created new space environment models and enhanced current theories using data from the Air Force's Communications/Navigation Outage Forecasting System and Solar Mass Ejection Imager (C/NOFS-SMEI) satellite missions. Investigated the theoretical underpinnings of active and passive space environment remediation techniques. Stimulated novel efforts to advance design, study, and development of new sensor technologies to observe cosmic rays and energetic charged particles from deep space in order to better quantify risks to Air Force systems. Researched simulation and				

visualization techniques to simplify complex data analysis and ensure future strategic awareness.

(U) In FY 2005: Not Applicable.

(U) In FY 2006: Not Applicable.

(U) In FY 2007: Not Applicable.

(U)

(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. Note: Prior to FY 2005, these efforts were part of other Major Thrusts earlier in this Project.	0.000	8.463	8.664	9.034

(U) In FY 2004: Not Applicable.

(U) In FY 2005: Exploit astronomical detection, tracking, and cataloging algorithms for enhanced protection of DoD surveillance capability in conjunction with data from the C/NOFS-SMEI satellites. Support development of ground-based advanced technology solar telescope adaptive optics systems, light detection and ranging radars, nanotechnology, and advanced signal-processing algorithms. Refine forecasting of ionosphere and space environment effects. Exploit 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. Continue 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, 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

Exhibit R-2a, RDT&E Project Justification			DATE: February 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2311 Space and Information Sciences	

	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. Further exploit data from DoD surveillance and the C/NOFS-SMEI satellites to improve remote sensing of interplanetary space. Further employ all-sky imaging to study of ionospheric plasma phenomena.				
(U)					
(U)	MAJOR THRUST: Investigate innovative technologies for space-based communication capabilities to ensure continued Air Force space dominance.	0.980	1.000	1.000	1.000
(U)	In FY 2004: Researched innovative methods for optical communications. Began probing novel techniques for potential bandwidth efficient modulation to enhance satellite communications. Started exploring the basic mechanisms of dual polarization antennas for space applications.				
(U)	In FY 2005: Examine innovative methods for optical communications. 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 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: Further examine 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. Note: Prior to FY 2005, these efforts were covered under Project 2304 in this Program Element.	0.000	4.211	4.306	4.786
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Improve data fusion science to permit rapid data conversion across multiple bands into graphical and conceptualized information. Promote methodologies to evaluate the performance of new wireless mobile, networked communications systems. Assess technical alternatives on the overall				

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
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	feasibility of super-resolution millimeter and search and rescue imagery. Solidify the hybrid radio-frequency/free-space optical paradigm and refine the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. Enable 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 radio-frequency/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: 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. Develop technology for super-resolution millimeter and search and rescue imagery. Further solidify the hybrid radio-frequency/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)					
(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 assurance, and information fusion. Note: Prior to FY 2005, these efforts were covered under Project 2304 in this Program Element.	0.000	10.770	11.359	11.825
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Continue research in information assurance for protection of future battlespace/infosphere systems and networks. Develop information fusion to provide deep, adaptive, expert decision support. Construct quantum computer devices and algorithms to allow enhanced tracking, recognition, and characterization to improve awareness and command and control. Design, implement, and evaluate 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 to improve situational awareness, command and				

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
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	control, and security. Begin to investigate first principles of software system architectures.				
(U)	In FY 2007: Continue to 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 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: Quantum Information Technology.	1.074	0.000	0.000	0.000
(U)	In FY 2004: Conducted fundamental scientific research associated with quantum information technologies.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Information Security and Cyber Counter Terrorism.	1.757	0.000	0.000	0.000
(U)	In FY 2004: Conducted fundamental scientific studies related to information security and cyber counter terrorism.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Chabot Space and Science Center.	1.952	1.982	0.000	0.000
(U)	In FY 2004: Supported the development of astronomical and scientific research and education capabilities at the Chabot Space and Science Center.				
(U)	In FY 2005: Increase 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: Demonstrating Space Research and Applications	0.000	0.991	0.000	0.000
(U)	In FY 2004: Not Applicable.				

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Space and Information Sciences**

(U)	In FY 2005: Support educational programming and exhibits that demonstrate the application of defense technology and research.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(U)	CONGRESSIONAL ADD: Network Information and Space Security.	0.000	2.478	0.000	0.000
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Conduct fundamental multi-disciplinary scientific research associated with network information and space security efforts.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)	Total Cost	20.064	29.895	25.329	26.645

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

	FY 2004 Actual	FY 2005 Estimate	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: 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 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2312 Biological Sciences	

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	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	9.130	9.546	9.827	9.886	10.342	10.604	10.803	10.983	Continuing	TBD
Quantity of RDT&E Articles	0	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 chemical and physical agent toxicity, 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 in toxicology explore the interaction of Air Force chemicals and physical agents (lasers and microwaves) with human tissues and associated effects to enable safety assessment strategies to ensure the hazard-free development and use of future air and space materials and directed energy systems. 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 cellular enzymes that will catalyze the synthesis of chemical feedstocks used in the safe production of space and air materials. 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. The primary areas of research investigated by this project are bio-informatics, profiling, and response; biocatalysis and bioenzymatic properties; and biomimetic, biomaterials, and biointerfacial sciences

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2004	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 jet fuels, nano-energetic materials, and directed energy. Identify, characterize, and engineer novel enzymatic properties that enable inexpensive and safe manufacture of unique, improved, or hard-to-make aerospace materials. Note: In FY 2004, "biocatalysis and bioenzymatic" efforts were moved from another Major Thrust later in this Project to this Major Thrust.	6.806	5.568	5.633	5.646

(U) In FY 2004: Pursued a biokinetics study of the uptake, biodistribution, metabolism, and elimination of JP-8 fuel in animals exposed through the inhalation and skin routes as a first step in assessing the risks of jet fuels. Extended research on molecular descriptors and mathematical expression of in vitro toxicity data to include data from genomics and proteomics profiles to rapidly predict computationally the toxicity of air and space chemicals. Extended sensitive genomics and proteomics profiling techniques to studies investigating the cellular and extra cellular effects of chronic and acute low-level exposures of animals to laser and microwave systems.

(U) In FY 2005: Model risks associated with exposure to fuels and complex mixtures. Analyze the biokinetics and biodistribution of JP-8 jet fuel components. Continue exploring, profiling, and modeling

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2312 Biological Sciences**

bio-informatics methodologies. Characterize, parameterize, and codify 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 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. Begin investigating the biomolecular profiles for underlying mechanisms associated with the 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.	2.324	3.978	4.194	4.240

(U) In FY 2004: Modeled the fundamental principles, processes, and designs of non-cryogenic infrared sensitive biosystems at the sub-cellular and molecular levels to enable future infrared materials, devices, and systems with enhanced structural and functional capabilities to identify, model, and construct near ambient infrared sensing devices. Enhanced adapting characteristics of microbial and protein-based biosystems for applications to military sensor systems. Explored mimicking natural materials, using organisms as factories of new materials, or taking existing biomaterials and processing them into Air Force useful materials. Studied the fundamental science and nano surface structure of biomaterials for application to military sensor systems that will ensure reliable assessment and monitoring.

(U) In FY 2005: Investigate, evaluate, and model natural occurrences, processes, and designs for future applications in infrared devices. Explore biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Exploit biomaterial

Exhibit R-2a, RDT&E Project Justification		DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2312 Biological Sciences**

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: Continue to investigate, evaluate, model, and mimic biological processes and designs for future applications in near ambient temperature sensing devices. 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 synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications.

(U) Total Cost	9.130	9.546	9.827	9.886

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

	FY 2004 Actual	FY 2005 Estimate	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: PE 0602202F, Human										
(U) Effectiveness Applied Research. PE 0602204F, Aerospace										
(U) Sensors. PE 0602602F, Conventional										
(U) Munitions. PE 0602702F, Command,										
(U) Control, and Communication.										

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2005

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT NUMBER AND TITLE: 2313 Human Performance

Cost ($ in Millions)	FY 2004 Actual	FY 2005 Estimate	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	12.471	10.503	10.385	10.641	10.488	14.494	14.784	15.044	Continuing	TBD
Quantity of RDT&E Articles	0	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 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 the scientific foundation for several 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 2004	FY 2005	FY 2006	FY 2007
	3.414	4.763	5.227	5.382

(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.

(U) In FY 2004: Investigated and modeled theories of sensory and perceptual systems. Evaluated theories and models of perception and cognition for more accurate simulation and improved fusion of sensor data. Examined visual information processing techniques to improve methods for evaluating display designs, enhancing the capability for collaboration, and improving the movement and sharing of information. Used performance metrics to critically test theories of sensory integration to understand complex images. Probed intrinsic differences in humans that make some individuals highly resistant to, and others highly susceptible to, sleep loss.

(U) In FY 2005: Conduct empirical research with mathematical and/or computational modeling in spatial audition, speech perception, and hearing protection. Assess multi-sensory integration methods and novel biological sensing mechanisms. Probe biophysical mechanisms responsible for fatigue. Evaluate 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

Exhibit R-2a, RDT&E Project Justification			DATE: February 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2313 Human Performance	

	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. Further study of the effects of ultrashort laser pulse on the eye (laser flash blindness).				
(U)					
(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.	4.631	5.740	5.158	5.259
(U)	In FY 2004: Extended models of the cognitive dimensions of human performance in complex command and control tasks to enable studies of automated decision-making and enhanced risk assessment and measured response. Tested models for enhanced human performance aided or augmented by intelligent systems. Explore mechanisms affecting training effectiveness of operator and team performance under stress and sustained operations.				
(U)	In FY 2005: Analyze models of enhanced human performance aided or augmented by intelligent systems. Assess mechanisms affecting training effectiveness for operator and team performance. Continue modeling relationships between individual skill differences and interactions with envisioned training. Explore 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 and methods for an improved understanding of individual and team information processing and decision-making. Continue to assess mechanisms affecting training effectiveness for individuals and teams. Continue modeling relationships between individual skill differences and interactions with envisioned training. Continue exploring measures to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload.				
(U)					

Exhibit R-2a, RDT&E Project Justification		DATE: February 2005
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2313 Human Performance

(U)	MAJOR THRUST: Study and test behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Note: In FY 2005, these efforts were moved to the "cognition and perception" Major Thrust earlier in this Project.	4.426	0.000	0.000	0.000
(U)	In FY 2004: Modeled relationships between individual skill differences and interactions with envisioned training techniques. Studied behavioral and physiological measures to avert human error in conditions of information overload and fatigue and maintain full spectrum air and space vigilance.				
(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)	Total Cost	12.471	10.503	10.385	10.641

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

	FY 2004 Actual	FY 2005 Estimate	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: PE 0602202F, Human 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 2005

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 2004 Actual	FY 2005 Estimate	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	7.232	12.428	7.798	8.571	8.908	18.159	18.528	18.862	Continuing	TBD
	Quantity of RDT&E Articles	0	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 2004	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Support the Air Force Research Laboratory international strategy mission. Note: In FY 2005, these efforts were moved to the "international science and technology" Major Thrust later in this Project.	2.559	0.000	0.000	0.000
(U) In FY 2004: Provided centralized international expertise to assist formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the Air Force. Provided the primary interface with the Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and the Air Force Materiel Command to coordinate international participation among appropriate Department of Defense (DoD) organizations.				
(U) In FY 2005: Not Applicable.				
(U) In FY 2006: Not Applicable.				
(U) In FY 2007: Not Applicable.				
(U)				
(U) MAJOR THRUST: Support international technology liaison missions, through the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development, to identify unique international research capabilities and make them available to the Air Force. Note: In FY 2005, these efforts were moved to the "international science and technology" Major Thrust later in this Project.	2.620	0.000	0.000	0.000
(U) In FY 2004: Enabled on-site coordination with international research organizations and supported international visits of high-level DoD delegations. Sustained and funded Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.				

Exhibit R-2a, RDT&E Project Justification			DATE February 2005
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **4113 External Research Programs Interface**	

(U)	In FY 2005: Not Applicable.				
(U)	In FY 2006: Not Applicable.				
(U)	In FY 2007: Not Applicable.				
(U)					
(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. Note: Prior to FY 2005, these efforts were part of other Major Thrusts earlier in this Project.	0.000	3.994	4.115	4.520
(U)	In FY 2004: Not Applicable.				
(U)	In FY 2005: Provide centralized cooperation expertise, support international technology liaison missions, and identify unique research capabilities of high interest to the U.S. Air Force. 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 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. 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. Assist in Air Force fiscal commitments to foreign NATO-affiliated research institutes.				
(U)					
(U)	MAJOR THRUST: Support scientist and engineer development assuring the Air Force of continuing availability of superior technical talent and forging Air Force Research Laboratory relationships with premiere scientists.	2.053	3.577	3.683	4.051
(U)	In FY 2004: Supported scientist and engineering research programs at U.S. colleges and universities,				

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including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Improved awareness of Air Force research needs throughout the civilian scientific community, while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.

(U) In FY 2005: 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 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 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)

(U) CONGRESSIONAL ADD: Minority LEADERS.	0.000	4.857	0.000	0.000
(U) In FY 2004: Not Applicable.				
(U) In FY 2005: Conduct 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	7.232	12.428	7.798	8.571

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

	FY 2004 Actual	FY 2005 Estimate	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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(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.