PE NUMBER: 0601102F
PE TITLE: Defense Research Sciences

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2008

BUDGET ACTIVITY: 01 Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

	Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	271.481	288.601	309.926	322.878	340.227	344.120	349.097	Continuing	TBD
2301	Physics	27.729	49.482	46.988	47.496	49.068	48.505	48.834	Continuing	TBD
2302	Solid Mechanics and Structures	16.463	16.926	18.028	19.936	20.378	20.348	19.797	Continuing	TBD
2303	Chemistry	33.523	33.562	38.233	38.420	39.532	39.591	39.508	Continuing	TBD
2304	Mathematics and Computing Sciences	30.165	24.135	30.586	33.430	36.027	36.373	37.994	Continuing	TBD
2305	Electronics	34.245	32.963	39.289	40.943	43.636	43.689	43.502	Continuing	TBD
2306	Materials	39.054	37.436	25.681	25.118	26.659	27.335	27.633	Continuing	TBD
2307	Fluid Mechanics	13.576	14.366	18.486	20.812	22.467	23.080	23.199	Continuing	TBD
2308	Propulsion	20.499	21.144	25.432	25.732	26.956	27.431	27.847	Continuing	TBD
2311	Information Sciences	26.008	25.257	31.640	32.512	36.241	38.062	39.045	Continuing	TBD
2312	Biological Sciences	9.682	10.332	10.473	10.601	10.444	10.230	10.120	Continuing	TBD
2313	Human Performance	12.161	11.052	15.255	18.065	19.220	19.538	21.299	Continuing	TBD
4113	External Research Programs Interface	8.376	11.946	9.835	9.813	9.599	9.938	10.319	Continuing	TBD

Note: In FY 2007, Project 2311 "Space and Information Sciences" changed its name to "Information Sciences" changed its name to "Information Sciences." In FY 2008, Space related efforts in Project 2311 and Physical Mathematics efforts in Project 2304 were moved into Project 2301 in this program element (PE) to more accurately align basic research efforts in Physics.

(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 2008, Congress added $0.8 million for Chabot Space and Science Center, $5.0 million for High Energy Laser for Detection, Inspection and Non-Destructive Testing, $2.0 million for Nanotechnology Based Biosensors and Biothreat Detectors, $0.7 million for UNR (University of Nevada-Reno) - Millimeter Wave-Based Fatigue Countermeasure Technology, $1.6 million for Fully-Integrated Solar-Powered Interior Lighting Technology, $1.0 million for Process Integrated Mechanism for Human-Computer Collaboration and Coordination, $1.6 million for Hybrid Materials for Thermal Management in Thin Films and Bulk Composites, $16.0 million for National Aerospace Leadership Initiative, $2.4 million for Development and Validation of Advanced Design Technologies for Hypersonic Research, and $1.0 million for Coal Transformation Laboratory. This program is in Budget Activity 1, Basic Research, because it funds scientific study and experimentation.

Exhibit R-2, RDT&E Budget Item Justification	DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences

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

		FY 2007	FY 2008	FY 2009
(U)	Previous President's Budget	281.156	258.259	263.012
(U)	Current PBR/President's Budget	271.481	288.601	309.926
(U)	Total Adjustments	-9.675	30.342	
(U)	Congressional Program Reductions		-0.018	
	Congressional Rescissions		-1.740	
	Congressional Increases		16.100	
	Reprogrammings	-3.672	16.000	
	SBIR/STTR Transfer	-6.003		

(U) Significant Program Changes:

Not Applicable.

C. Performance Metrics

(U) Under Development.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2301 Physics	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2301 Physics	27.729	49.482	46.988	47.496	49.068	48.505	48.834	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: Space Environment efforts from Project 2311 and Physical Mathematics efforts from Project 2304 moved to this Project in FY 2008 to more accuarately align basic research efforts in Physics.

(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; space sensors and imaging physics; space environment physics; electromagnetics; and applied analysis.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and multi-aperture adaptive optics.	9.274	9.418	10.609
(U) In FY 2007: Investigated new laser materials and configurations to enable efficient, high power, and wide wavelength tunable lasers. Investigated arrays of micro-discharges for laser devices and pumps, as well as other intense light source applications. Explored use of directed energy beams for direct-write materials processing techniques that offer new microsystems fabrication and packaging capabilities. Studied semiconductor laser and nonlinear optical devices for improved application to infrared countermeasures.			
(U) In FY 2008: Study mechanical, optical, and laser properties of ceramic materials as a function of material and preparation parameters. Investigate novel index, gain and doping profiles for high power, high beam, quality ceramic lasing. Study means for efficiently producing and making available quasi-phase matched semiconductor crystals for tunable high energy lasing. Study fundamental and practical limitations on efficiency and high temperature operation of mid-infrared semiconductor lasers, which have shown great promise for heat seeking missile countermeasures.			
(U) In FY 2009: Investigate applications of previous research enabling large inexpensive, very bright micro-plasma array ultraviolet sources to large flexible displays, materials curing, biological agent decontamination, and infectious disease treatment. Continue and expand research on high energy, tunable, all solid state lasers. Study direct-write micro-systems, including on-board power sources. Apply 3-D laser write techniques in special glasses to inexpensive, flexible subsystems for space.			
(U)			
(U) MAJOR THRUST: Explore high-energy, electro-energetic device concepts and manipulate atomic and molecular	13.097	13.162	14.353

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2301 Physics

(U) B. Accomplishments/Planned Program ($ in Millions) FY 2007 FY 2008 FY 2009

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.

(U) In FY 2007: Characterized the interactions of atoms and molecules in strong electromagnetic fields. Examined techniques for precision measurement of atomic and molecular properties, atomic collision processes, and fundamental interactions between atoms, molecules, ions, and radiation. Explored dynamic molecular interactions in combustion and high energy density propellants. Studied electro-energetic concepts related to non-lethal weaponry. Explored high power, high frequency electromagnetic device concepts and studies of new compact pulsed power technologies. Explored use of electron beam generated microwaves for high-bandwidth communications, advanced long-distance covert surveillance, electronic countermeasures, and directed energy weapons. Investigated ultra-high current density cathode concepts. Initiated advanced modeling and simulation of electro-energetic phenomena. Studied overlapped research areas between atomic physics and condensed matter physics. Resolved basic scientific issues blocking realization of electromagnetic launch concepts.

(U) In FY 2008: Explore usage of ultra-cold atoms and molecules for precision inertial navigation system components and ultra-precise measurement techniques using the results of previous research into atomic collision processes and fundamental interactions between atoms, molecules, ions, and radiation. Explore the possibility of tailor-making materials using the results of research in the overlap between atomic physics and condensed matter physics. Continue exploring new concepts for high-power, high-frequency electromagnetic radiation sources. Study quantum physics effects relating to the emission of electrons from surfaces. Examine the application of Chaos Theory effects to raise fundamental limits on electrical energy storage density. Study the seamless integration of magnetohydrodynamic and particle-in-cell modeling algorithms to better capture the detailed physics of high power microwave sources.

(U) In FY 2009: Continue studying the usage of ultra-cold atoms and molecules for precision inertial navigation system components and ultra-precise measurement techniques using the results of previous research into atomic collision processes and fundamental interactions between atoms, molecules, ions, and radiation. Continue exploring the possibility of tailor-making materials using the results of research in the overlap between atomic physics and condensed matter physics. Exploit emerging microfabrication methodologies for the realization of compact, high-frequency, high-power electromagnetic radiation sources. Continue studying quantum effects impacting electron emission from surfaces. Expand Chaos Theory studies to raise fundamental limits on electrical energy storage density. Create new simulation codes embodying both magnetohydrodynamic and particle-in-cell algorithms to realistically model high power microwave sources.

(U)

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2301 Physics**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	MAJOR THRUST: Advance technologies for space sensors, imaging, identification, and tracking methods, and effective space situational awareness.	4.608	4.680	5.871
(U)	In FY 2007: Studied fundamental issues that affect remote sensing, including propagation, image formation, and image recovery processes. Identified, characterized, and modeled parameters enabling remote sensing, locating, and precision tracking of objects, particularly from space and of space objects from the ground. Studied environmental effects on sensors and sensor systems and of the effects of the medium through which the signal propagates.			
(U)	In FY 2008: Develop theoretical approaches to the surveillance and identification of space objects from both the ground and from space. Continue to study propagation of electromagnetic energy, image formation, image recovery, and information content maximization from both ground-based and space-based sensors. Investigate methods to mitigate environmental effects on sensors and sensor systems. Investigate atmospheric density forecast models to improve satellite orbit determination and tracking.			
(U)	In FY 2009: Continue to investigate fundamental limits affecting ground-based and space-based surveillance of space objects. Develop improved adaptive optics and post-processing techniques for improved image resolution. Study spectral, polarimetric, and temporal approaches to unresolved space object identification. Continue the study of fundamental processes in the solar-terrestrial system that affects atmospheric density to lead to physics-based methods of satellite orbit prediction and precision tracking.			
(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: In FY 2008, Space Environment efforts previously in Project 2311 in this PE were moved into this Project to more accurately align basic research efforts in Physics.	0.000	4.919	6.110
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Begin using newly developed radio telescope instruments to probe the near-Earth space environment, to study solar phenomena, and to develop innovative methods for remote sensing the space environment as well as for heliospheric tomography. Investigate fundamental plasma modeling theory using new grid-free, full kinetic modeling techniques, and develop novel techniques to include electromagnetism. Continue development of ground-based and space-based sensor technology for remote sensing and in situ measurement of space weather conditions. Continue to seek understanding of fundamental physics and processes controlling solar, heliospheric, magnetospheric, ionospheric, and thermospheric environments with a focus on improving forecast capabilities of the near-Earth space environment using first principles physics models. Continue developing understanding of fundamental processes of			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2301 Physics

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
energetic particle scattering in the near-Earth environment to support protection of space assets and to explore the solar interior as a complex system through advanced modeling techniques. Continue to analyze data from DoD surveillance satellites to improve remote sensing of interplanetary space. Maintain focused research to investigate the neutral densities and winds above 150 kilometers.			
(U) In FY 2009: Emphasize development of cost - effective micro satellites for space weather sensing. Investigate requirements of boundary conditions and initial values for driving space weather models. Exploit newly developed radio astronomy techniques for remote sensing the space environment in the continued search for understanding of fundamental physics and processes controlling solar, heliospheric, magnetospheric, ionospheric, and thermospheric environments with a focus on improving our ability to forecast near-Earth space environment using first principles physics models. Expand investigation of the fundamental plasma modeling theory using new electromagnetic, grid-free, full kinetic modeling techniques. Continue ground-based and space-based sensor technology development for remote sensing and in situ measurement of space weather conditions. Continue developing understanding of fundamental processes of energetic particle scattering in the near-Earth environment to support protection of space assets and to explore the solar interior as a complex system through advanced modeling techniques. Continue to analyze data from DoD surveillance satellites to improve remote sensing of interplanetary space. Maintain focused research to investigate the neutral densities and winds above 150 kilometers for satellite drag.			
(U)			
(U) MAJOR THRUST: Research physical mathematics and applied analysis to develop accurate models of physical phenomena to enhance the fidelity of simulation. Conduct research in electromagnetics to produce conceptual descriptions of electromagnetic properties of novel materials/composites and simulate their uses in various operational settings. Note: In FY 2008, Physical Mathematics efforts previously in Project 2304 in this PE were moved into this project to more accurately align basic research efforts in Physics.	0.000	8.854	10.045
(U) In FY 2007: Not Applicable.			
(U) In FY 2008: Continue to investigate properties of coherently propagating ultra-short laser pulses through the atmosphere with an emphasis on their ability to propagate through clouds and be used for target imaging. Continue to develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media with an emphasis on designs for 199KW laser weapons. Continue to investigate the dynamics of transonic/supersonic/hypersonic platforms, with an emphasis on stores release. Model the effects of the dynamics of the upper atmosphere on the stability of high altitude platforms as well as to assure the effective uses of their optical inventory. Study the design of reconfigurable warheads through suitable timing/placement of micro-detonators, together with effects of metal particle inclusions. Continue to improve methods for recognizing and tracking targets			

Exhibit R-2a, RDT&E Project Justification		DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2301 Physics

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	and for penetrating coverings or other dispersive media that obscure targets so that radar emitting suitable waveforms can be used to image through foliage and clouds. Pursue the design of electromagnetic sources which, with the help of novel materials, can transmit optimized waveforms for a variety of surveillance purposes.			
(U)	In FY 2009: Investigate properties of coherently propagating ultra-short laser pulses through the atmosphere for their exploitation as high power microwave sources. Upgrade algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media so that simulation of various lasers can be realized. Initiate a modeling/simulation effort to codify the theoretical work on the dynamics of transonic/supersonic/hypersonic platforms to verify that designs and operations are near optimal. Model the effects of the dynamics of the upper atmosphere on the stability of high altitude platforms, as well as to assure the effective uses of their optical inventory. Communicate these results to the airborne laser program and to the Air Force's Air Combat Command, for the latter's high altitude platforms. Verify the design of reconfigurable warheads through suitable timing/placement of micro-detonators, as well as the effects of various metal inclusions on lethality. Continue to improve methods for recognizing and tracking targets and for penetrating coverings or other dispersive media that obscure targets. Pursue the design of electromagnetic sources which, with the help of novel materials, can transmit optimized waveforms for a variety of surveillance purposes and write numerical code which allows the user to simulate these sources.			
(U)				
(U)	CONGRESSIONAL ADD: Non-Lethal Stunning/Immobilizing Weapons	0.750	0.000	0.000
(U)	In FY 2007: Accelerated fundamental scientific investigations in non-lethal stunning and immobilizing weapons research			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Chabot Space and Science Center	0.000	0.795	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Develop new science programs for K-12 students, teachers, and the general public.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: High Energy Laser for Detection, Inspection and Non-Destructive Testing	0.000	4.970	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Conduct laser technology research to support multiple applications, including inspection of military hardware and equipment flaws, and detecting weapons hidden in cargo ships.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2301 Physics

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Nanotechnology Based Biosensors and Bio-Threat Detectors	0.000	1.988	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Research to remotely control the operation of both nanofabrication equipment and nanoscale analysis tools while performing new nano related science field. In addition, a significant number of minority engineers will be trained in nanotechnology research area.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: UNR - Millimeter Wave-Based Fatigue Countermeasure Technology	0.000	0.696	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Develop a novel device based on millimeter wave technology that will serve as a skeletal muscle fatigue countermeasure for use in the battlefield.			
(U)	In FY 2009: Not Applicable.			
(U)	Total Cost	27.729	49.482	46.988

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 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.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2301 Physics**

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
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 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2302 Solid Mechanics and Structures	16.463	16.926	18.028	19.936	20.378	20.348	19.797	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(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.	7.773	8.027	8.578

(U) In FY 2007: Expanded 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. Developed the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Developed and exploited methods that combine information technology and modeling in the design of new material systems and devices at multiple scales.

(U) In FY 2008: Expand research in the area of multi-functional composite systems with structurally integrated antenna functions of broad bandwidth and improved structural endurance. Continue research in the areas of diagnostics, prognostics, autonomics, self-healing, thermal management, energy harvesting/storage, and micro-/nano-mechanics to enable safer and more durable aerospace structures with improved performance characteristics. Further develop the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Continue developing and exploiting methods that combine information technology and multi-scale modeling in the design of new material systems and devices.

(U) In FY 2009: Continue research in the area of multi-functional hybrid composite systems for sensing and neutralization of exogenous threats to load-bearing capability. Continue research in the areas of diagnostics, prognostics, autonomics, self-healing, thermal management, energy harvesting/storage, electromagnetic energy radiation/transmission, and micro-/nano-mechanics to enable safer and more durable aerospace structures with

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2302 Solid Mechanics and Structures**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	improved performance characteristics. Further develop the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Continue developing and exploiting methods that combine information technology and multi-scale modeling in the design of new material systems.			
(U)				
(U)	MAJOR THRUST: Analyze structural fatigue and mechanics, adaptive structures, and material properties to improve the design, robustness, and performance of air and space systems to include multi-mission unmanned aerial vehicles (UAVs).	8.690	8.899	9.450
(U)	In FY 2007: Explored novel methods for constructing and modeling morphing structures that broaden system operational capabilities. Developed novel actuation devices and materials for applications such as micro-UAV aircraft and space structures. Utilized acquired knowledge of material behavior in aerospace structure to develop system lifetime prognosis methodologies. Developed structural health monitoring techniques and systems and exploration of mechanical and dynamic behavior of micro-/nano-scale structures. Investigated nonlinear phenomena, such as structural deformation and aero-elastic effects in novel structural applications.			
(U)	In FY 2008: Develop novel theoretical and experimental methods for constructing and modeling morphing structures that broaden system operational capabilities. Continue development of novel actuation devices and materials for a variety of Air Force applications to aircraft and space structures. Study the science issues related to the introduction into new structural concepts of the novel materials developed under the advanced materials programs. Use the knowledge acquired about the novel materials to develop new aerospace structural concepts. Develop an integrated approach to structural systems lifetime prognosis. Continue the development of structural health monitoring sensors and techniques towards an integrated vehicle-wide approach. Consolidate the exploration of mechanical and dynamic behavior of micro-/nano-scale structures. Expand the investigation of nonlinear phenomena associated with the structural deformation and aero-elastic instabilities and limit-cycle vibration to include novel structural concepts.			
(U)	In FY 2009: Expand the novel theoretical and experimental methods in morphing aircraft structures to achieve broader operational capabilities. Utilize novel actuation devices and materials for Air Force aircraft and space structural applications. Expand the study of the science related to the acceptance into new structures of the novel materials developed under the advanced materials programs. Use this acquired knowledge to develop new aerospace structural concepts. Continue the development of structural health monitoring sensors and techniques towards an integrated vehicle-wide approach. Consolidate an integrated approach to structural systems lifetime prognosis and reliability. Expand the understanding of mechanical and dynamic behavior of micro-/nano-scale structures to			

Exhibit R-2a, RDT&E Project Justification		DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2302 Solid Mechanics and Structures

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

		FY 2007	FY 2008	FY 2009
	generate novel structural concepts. Continue investigation of nonlinear phenomena associated with the structural deformation and aero-elastic instabilities and limit-cycle vibration to include novel structural concepts.			
(U)	Total Cost	16.463	16.926	18.028

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(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 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2303 Chemistry	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2303 Chemistry	33.523	33.562	38.233	38.420	39.532	39.591	39.508	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Research and characterize molecular dynamics, reaction mechanics/interactions, and theoretical chemistry to model, predict, control, and exploit atomic and molecular energetics for advanced fuels, munitions, and countermeasure techniques.	13.653	14.423	16.510

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

(U) In FY 2008: Develop new theoretical and computational methods to enhance capabilities to predict and simulate properties of chemicals and materials of interest to the Air Force. Continue to develop new experimental methods to advance understanding of reactivity and energy flow in molecules for applications to signatures, battlespace awareness, propellants, munitions, and laser systems. Explore ability to understand and control catalysis and plasmonic structures to enhance propulsion and energetic applications and sensitive detection of target compounds.

(U) In FY 2009: Continue to develop new capabilities to predict molecular and macroscopic properties of chemicals of interest to the Air Force. Explore properties and potential of nano-scale energetic materials. Continue to develop new experimental methods to advance understanding of reactivity and energy flow in molecules for applications to signatures, battlespace awareness, propellants, munitions, and laser systems. Continue to develop novel applications

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2303 Chemistry**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	of catalysis and plasmonic structures for applications to propulsion, energetics, and sensing. Explore new concepts for closed-cycle hybrid chemical lasers.			
(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.	9.488	10.134	12.221
(U)	In FY 2007: Utilized nanotechnology to enhance chemical and physical properties of polymers. Exploited photorefractive polymer as a medium for wavefront correction in optical communication and imaging. Explored flexible structures that can provide functions such as sensing, power generation and storage, electronics, and other functionalities for smart skin and multi-functional structures.			
(U)	In FY 2008: Explore power generation and power storage for warfighters based on improved polymers for solar cells and fuel cells applications. Continue to explore photonic polymers and conductive polymers for communications and detections. Investigate 3-D displays based on photorefractive polymers. Polymers with controlled dielectric permittivity and magnetic permeability will be explored for advanced radar antenna applications. Control growth mechanisms of carbon single wall nanotubes will be investigated.			
(U)	In FY 2009: Continue to exploit nanotechnology to enhance functional and mechanical properties of polymers through controlled dispersion, distribution, and placement of the nano-entities for Air Force applications. Control synthesis of new polymers with improved power generation and storage functions will be explored. Modeling, synthesis, and characterization of conjugated polymers will be conducted to understand and enhance the charge mobility of organic based semi-conducting organics and polymers.			
(U)				
(U)	MAJOR THRUST: Expand the fundamental chemistry and physics of surfaces and interfacial processes pertaining to corrosion protection, wear reduction, and power storage for air and space systems.	6.873	7.414	9.502
(U)	In FY 2007: Explored 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. Investigated phenomena at surface interfaces, including friction and wear, lubrication, corrosion and degradation, sensing, electrochemical energy storage, and electrochemically induced reaction products and kinetics. Created and characterized novel multi-functional surface structures, coatings, covers, and lubricants. Investigated novel biophysical mechanisms for catalysis and survivability in compact electronic, power, and sensing applications.			
(U)	In FY 2008: 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. Continue to investigate			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2303 Chemistry

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	phenomena at surface interfaces, including friction and wear, lubrication, corrosion and degradation. Explore novel approaches to corrosion prevention, particularly multi-disciplinary efforts that combine corrosion initiation, detection, and lifetime prediction. Continue tribological investigations that focus on bridging the fundamental gap between macro and nano scale mechanisms, including heat transfer, chemical reactivity, and atmospheric effects. Continue to investigate nano-scale surface structures for power applications.			
(U)	In FY 2009: Continue to 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. Continue to investigate phenomena at surface interfaces, including friction and wear, lubrication, corrosion and degradation. Explore novel approaches to corrosion prevention, particularly multi-disciplinary efforts that combine corrosion initiation, detection, and lifetime prediction. Continue tribological investigations in nanocomposite lubricants that provide function over a wide variety of extreme environments, including space.			
(U)				
(U)	CONGRESSIONAL ADD: New Methods for Designing and Testing Aircraft Coatings.	1.559	0.000	0.000
(U)	In FY 2007: Conducted research to explore environmentally friendly and longer-lasting anti-corrosion coatings for aging aircraft.			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Smart Surfaces and Interfaces	0.975	0.000	0.000
(U)	In FY 2007: Conducted research to explore surfaces and interfaces that respond smartly to the surroundings.			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Fully-Integrated Solar-Powered Interior Lighting Technology.	0.975	1.591	0.000
(U)	In FY 2007: Conducted research to integrate solar-energy-generating photovoltaic materials and light-emitting organic materials for self-contained lighting systems for combat locations.			
(U)	In FY 2008: Continue to conduct research to integrate solar-energy-generating photovoltaic materials and light-emitting organic materials for self-contained lighting systems for combat locations.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	Total Cost	33.523	33.562	38.233

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2303 Chemistry**

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 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 2008
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 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2304 Mathematics and Computing Sciences	30.165	24.135	30.586	33.430	36.027	36.373	37.994	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2008, Physical Mathematics efforts in this Project moved to Project 2301 within this PE to more accurately align basic research efforts in Physics.

(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, optimization and discreet mathematics, and computational mathematics.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(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. Increasing level of efforts in basic research on complex networks require monetary increases in this major thrust.	9.300	11.928	15.650

(U) In FY 2007: Improved 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. Developed control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Improved image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Investigated methods for design and analysis of bio-inspired sensing systems, controls, and computational systems. Developed algorithms for control of and over dynamic, large-scale networks.

(U) In FY 2008: Investigate emerging novel approaches for cooperative control systems in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Conduct additional research for teams of micro air vehicles operating at various altitudes in complex environments to execute assigned missions with variable operator intervention. Advance control methodologies and modeling to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Continue to advance image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Advance methods for design and analysis of bio-inspired sensing systems, controls, and computational systems. Continue development of algorithms for control of and over dynamic, large-scale networks. Investigate theory and algorithms for specification, design, verification, and validation of distributed embedded systems. Research potential devices to exploit nonlinear

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2304 Mathematics and Computing Sciences

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
dynamic phenomena with a focus on detection, classification, and control systems for use in urban combat environments.			
(U) In FY 2009: Further develop the design and analysis techniques for cooperative control systems in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Continue additional research for teams of micro air vehicles operating at various altitudes in complex environments to execute assigned missions with variable operator intervention. Continue developing control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems. Continue to advance image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Develop methods for design and analysis of bio-inspired sensing systems, controls, and computational systems. Continue development of algorithms for control of and over dynamic, large-scale networks. Develop theory and algorithms for specification, design, verification, and validation of distributed embedded systems. Design novel devices to exploit nonlinear dynamic phenomena with a focus on detection, classification, and control systems for use in urban combat environments.			
(U)			
(U) MAJOR THRUST: Research physical mathematics, applied analysis, and electromagnetics. Note: In FY 2008, efforts previously in this Major Thrust were moved into Project 2301 in this PE to more accurately align basic research efforts in Physics.	9.787	0.000	0.000
(U) In FY 2007: Developed enhanced models of physical phenomena to advance the fidelity of simulations. Investigated properties of coherently propagating ultra-short laser pulses through the atmosphere. Developed algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media. Investigated the dynamics of transonic/supersonic/hypersonic platforms. Studied the design of reconfigurable warheads through suitable placement of micro-detonators. Improved methods for recognizing and tracking targets and for penetrating coverings or other dispersive media that obscure targets.			
(U) In FY 2008: Not Applicable.			
(U) In FY 2009: 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.	11.078	11.213	14.936
(U) In FY 2007: Elucidated complex problems in system diagnostics/prognostics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Developed innovative methods and			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2304 Mathematics and Computing Sciences**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	algorithms that will improve modeling and simulation capabilities. Integrated new multi-disciplinary design optimization strategies with high-order, time-accurate solutions for superior design of jet engines, directed energy devices, munitions and penetrators, air and space components, and system health and maintenance systems. Developed mathematical method for solving large or complex problems in logistics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Enhanced uncertainty analysis in non-linear models of aerodynamic flows and structural failure predictions.			
(U)	In FY 2008: Continue to develop mathematical methods for solving large and complex problems in logistics, system diagnostics/prognostics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Approaches will include both rigorous analytical tools and meta heuristic searches. Continue to develop innovative mathematical and numerical algorithms that will improve modeling and simulation capabilities in order to increase understanding, prediction, and design of large and complex phenomena of interest to the Air Force. These phenomena include aerodynamics for various flight regimes, high power microwaves, material design, and structural mechanics. Continue to develop and 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, micro air vehicles, air and space components, and system health and maintenance systems. Enhance uncertainty quantification based on rigorous error analysis in non-linear models of aerodynamic flows and structural failure predictions. Develop mathematical models that are dynamically evolving that would deal with operational data that are possibly incomplete, uncertain, conflicting, or overlapping.			
(U)	In FY 2009: Develop rigorous mathematical methods for solving large and complex problems in logistics, system diagnostics/prognostics, air mobility contingencies, target tracking, and strategic/tactical planning for battlespace information management. Enhance the analytical tool developments in operation research, meta heuristic searches, and robust and stochastic optimization. Focus on developing innovative and accurate mathematical and numerical algorithms that will improve modeling and simulation capabilities. These phenomena include aerodynamics as applicable to a range of flight regimes such as hypersonics and micro air vehicles. Continue to develop and 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 enhance uncertainty analysis in non-linear models of aerodynamic flows and structural failure predictions. Continue to develop mathematical models that are dynamically evolving that would deal with operational data that are possibly incomplete, uncertain, conflicting, or overlapping.			
(U)				
(U)	CONGRESSIONAL ADD: Process Integrated Mechanism for Human-Computer Collaboration and Coordination	0.000	0.994	0.000

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2304 Mathematics and Computing Sciences

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

	FY 2007	FY 2008	FY 2009
(U) In FY 2007: Not Applicable.			
(U) In FY 2008: Develop a novel technology of a process integrated mechanism, which ties together computers and humans into a single collaborating system by virtue of a single program that rapidly moves between all the computers in the system.			
(U) In FY 2009: Not Applicable.			
(U) Total Cost	30.165	24.135	30.586

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 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			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2305 Electronics	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2305 Electronics	34.245	32.963	39.289	40.943	43.636	43.689	43.502	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Electronics basic research generates and exploits fundamental knowledge and understanding of novel solid - state electronic, sensor, and optoelectronic materials and device implementation schemes vital to advance Air Force operational capabilities in surveillance, information and signal processing, communications, command and control, electronic countermeasures, stealth technologies, and directed energy weapons. Solid - state electronics research discovers and develops new materials, advances processing and fabrication sciences, and develops and implements advanced physical modeling and simulation capabilities essential to evaluate novel electronic, sensor, and optoelectronic structures and device concept implementation schemes. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability, while simultaneously reducing component and system power, size, mass, and life cycle costs.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Investigate novel detector and electronic materials, device concepts, and circuit architecture and implementation schemes important to future military space platforms for increased system reliability, survivability, and functionality, while simultaneously reducing component power, size, and mass. Research is focused on high-risk, innovative, and potential-breakthrough materials, devices, and circuit concepts enabling future generation high-sensitivity multi-spectral detection, high-speed and high-throughput data processing, high-density non-volatile data storage, and advanced high-power, broad-band, highly efficient X-W band radar and communications.	7.546	7.785	9.366

(U) In FY 2007: Investigated novel materials for reconfigurable electronics produced from major review of entire program. Researched efforts on wide bandgap gallium nitride materials and devices and transitioned to major Defense Advanced Research Projects Agency (DARPA) program. Linked university nanosatellite projects to key DoD and commercial space interests, and more aggressively sought space launches for the best nanosatellite projects.

(U) In FY 2008: Investigate novel reconfigurable multi-functional electronic materials that show potential for dynamically tailoring their physical properties via application of one or more 'stimuli', such as electric and/or magnetic fields, optical signals, heat, mechanical stress, chemical processes, etc., with the end objective of precisely tuning their physical properties in response to dynamically changing electronic and/or optoelectronic device, circuit, or system requirements, such as that driven by natural or radiation induced degradation and/or changing mission requirements. Investigate innovative multi-spectral and multi-phenomenology-based detector concepts/approaches utilizing breakthroughs in material electronic bandgap and defect-band tuning concepts, absorption phenomenology-based detection mechanisms, novel material and device functionality, novel hetero-material interfacing and interconnect schemes, and biologically-based detection processes.

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2305 Electronics

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	In FY 2009: Continue investigating novel innovative reconfigurable multi-functional electronic materials, material bandgap and defect-band tuning concepts, phenomenology-based detection mechanisms, novel hetero-material interfacing and interconnect schemes, and novel nanoscience and biologically-based detection processes. Investigate 'smart' reconfigurable materials whose properties can be dynamically tailored via self-programming or system software in response to changing behavior or mission needs. Focus on novel 'programmable pathways' to enable tailoring novel hybrid material systems such as metamorphic and heterogeneous systems.			
(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.	14.450	14.245	15.827
(U)	In FY 2007: Investigated nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Explored nanoelectronics, nanophotonics, and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency lasers wavelength-diverse, high sensitivity detectors. Examined advanced optical memory technologies for enhanced data storage. Investigated technologies for robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Investigated communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments.			
(U)	In FY 2008: Continue to investigate nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Continue to explore nanoelectronics, nanophotonics, spintronics and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency wavelength-diverse lasers, high sensitivity detectors. Further the examination of advanced optical memory technologies for enhanced data storage, including negative index of refraction metastructures. 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)	In FY 2009: Further investigate nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Continue to explore nanoelectronics, nanophotonics, spintronics, multi-functional materials, and other advanced optoelectronic, magnetic, and electronic materials and devices for lower power consumption, high-efficiency wavelength-diverse lasers, high sensitivity			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2305 Electronics

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	detectors. Further the examination of advanced optical memory technologies for enhanced data storage, including negative index of refraction metastructures and photonic crystals. Investigate technologies for robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers, as well as plasmonics. 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.	5.091	5.258	6.839
(U)	In FY 2007: Developed techniques to control growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Developed nanoelectronics and nanophotonics for guided wave and free space optoelectronic device technology and methods for their integration to enable chip-scale optical networks that will overcome future interconnect problems. Explored nanophotonic concepts for information processing components and systems.			
(U)	In FY 2008: Further develop and refine techniques to control growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Test functionalities of structural materials and improve growth methods. Continue developing nanoelectronics and nanophotonics for guided wave and free space optoelectronic device technology and methods for their integration to enable chip-scale optical networks that will overcome future interconnect problems. Continue exploring nanophotonic concepts for information processing components and systems.			
(U)	In FY 2009: Exploit controlled growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Continue testing functionalities of structural materials and improve growth methods. Continue developing and improving knowledge of nanoelectronics and nanophotonics for guided wave and free space optoelectronic device technology and methods for their integration to enable chip-scale optical networks that will overcome future interconnect problems. Continue exploring nanophotonic concepts for information processing components and systems.			
(U)				
(U)	MAJOR THRUST: Investigate quantum electronic solids phenomena to explore superconducting, magnetic, negative index, and nanoscopic materials to produce superconducting tapes for compact power generators and magnets, and for advanced sensors, communications, lightweight antennas, signal processing, and ultra-dense memory.	5.500	5.675	7.257
(U)	In FY 2007: Exploited methodologies to fabricate new high current, high-temperature superconducting materials for			

Exhibit R-2a, RDT&E Project Justification		DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2305 Electronics

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	enhanced power generation and storage devices. Searched for high-temperature superconductors. Developed high-temperature magnetic materials for power devices, switches, and bearings in aircraft electrical systems. Searched for 3-D negative index materials in the infrared and visible regions, and used those materials to make circuit elements with smaller size and increased functionality.			
(U)	In FY 2008: Recent success in increasing current-carrying properties of high-temperature superconducting short sections of tape will be exploited to increase those properties in longer lengths and attempts will be made to reduce eddy-current loses. Microwave properties of high-temperature superconductors will receive added emphasis because of recent progress in reducing losses at high frequencies. The goal is to provide thin-film superconducting material that can provide improved radar systems and compact communications systems. The search for practical even higher-temperature superconductors will continue. Efforts to create true 3-D negative index material at frequencies from microwave to infrared and visible will be augmented. The search for higher-temperature, high-energy-product magnetic materials will continue using innovative nanomaterial technology. Using carbon nanotubes and other nanomaterials, new compact architectures will be created to further miniaturize devices for signal processing, memory storage, and sensing.			
(U)	In FY 2009: Using improved planar thin-film Josephson-junction technology, a low-noise, wide-bandwidth amplifier will be constructed and tested. Attempts to fabricate high-temperature, high-performance magnetic materials will be given greater emphasis in providing support for the More Electric Airplane and other advanced systems. Studies to reduce eddy-current losses and to prevent quenching in superconducting tapes will be augmented as the tape technology reaches desired goals. Progress in seeking practical negative index materials over a broad range of frequencies will continue. Nanoelectronic circuitry based on nanomaterials and new concepts also will receive added emphasis in attempting to promote miniaturization, greater functionality, and lower losses. Searches for new higher-temperature (and practical) superconductors will continue.			
(U)				
(U)	CONGRESSIONAL ADD: Nanophotonic Components.	1.658	0.000	0.000
(U)	In FY 2007: Conducted basic research in nano-materials and nano-manufacturing for military photonic applications.			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)	Total Cost	34.245	32.963	39.289

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
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 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 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 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2306 Materials	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2306 Materials	39.054	37.436	25.681	25.118	26.659	27.335	27.633	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Materials basic research enhances the performance, cost, and reliability of structural materials to eliminate reliability issues related to high-temperature strength, toughness, fatigue, and environmental conditions. This research expands fundamental knowledge of material properties that leads to the development of novel materials for airframe, turbine engine, and spacecraft structures. The goals of this project are to develop improved materials for air and space vehicles that provide increased structural efficiency and reliability, increase the operating temperature of engine materials, and further increase thrust-to-weight ratio of engines. A primary research focus 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 2007	FY 2008	FY 2009
(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.	9.266	9.481	12.351

(U) In FY 2007: Optimized the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Exploited new approaches to designing multi-functional structural ceramics materials to enable structurally enhanced smart systems for application in extreme environments. Investigated high-temperature resistant and joining methodologies for lightweight ceramic materials. Examined innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Developed nanomaterials and nanocomposites that will enable reduced system weight and/or size, increased operational lifetime, and multi-functional performance of load-bearing aerospace structures.

(U) In FY 2008: Continue to optimize the design of multi-functional structural ceramics materials to enable structurally enhanced smart systems for application in extreme environments. Exploit new approaches in improving the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Further develop high-temperature resistant and joining methodologies for lightweight ceramic materials. Continue to develop innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Continue to develop the fundamental knowledge base to exploit the use of nanomaterials and nanocomposites in aerospace structures.

(U) In FY 2009: Continue optimizing the design of multi-functional structural ceramics materials to enable structurally enhanced smart systems for application in extreme environments. Expand the development of new approaches in

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2306 Materials**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	improving the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Continue to further develop high-temperature resistant and joining methodologies for lightweight ceramic materials. Expand the development of innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Continue to expand the development of the fundamental knowledge base to exploit the use of nanomaterials and nanocomposites in aerospace structures.			
(U)				
(U)	MAJOR THRUST: Research metallic materials and identify relationships between structures (including microstructures), processing, properties, and performance so as to develop affordable and durable metallic systems for advanced engines and aerospace structural applications.	10.288	10.460	13.330
(U)	In FY 2007: Investigated lightweight structural materials, refractory metals, intermetallic alloys, amorphous alloys and their composites, and micro-laminated materials for sustainable use in aerospace applications. Developed and verified physics-based, quantitative, predictive models that relate processing, chemistry, and structure with properties and performance of metallic materials.			
(U)	In FY 2008: Continue investigating metallic materials for sustainable use in structural applications and advanced engines. Investigate nano-laminates and nano-composites for aerospace armor and small air vehicle structures. Explore the interaction between chemistry and mechanics in surfaces and interfaces of these nanoscale structures. Explore the processing and development of multifunctional structural metals for power systems and space applications. Capitalize on advances in multi-scale modeling to study the response of aerospace alloys exposed to corrosive environments and cyclical loading. Develop an informatics process exploiting disparate sources of materials' properties data derived from modeling and experimentation. Explore the fundamental science of friction and thermal effects during friction stir processing.			
(U)	In FY 2009: Further investigate nano-laminates and nano-composites for aerospace armor and small air vehicle structures. Explore the interaction between chemistry and mechanics in the surfaces and interfaces of these nanoscale structures. Further explore the processing and development of multifunctional structural metals for power systems and space applications. Further develop and verify multi-scale models to study the response of aerospace alloys exposed to corrosive environments and cyclical loading. Continue development of an informatics process to exploit disparate sources of materials' properties data derived from modeling and experimentation. Continue research on the fundamental science of friction and thermal effects during friction stir processing. Investigate affordable and environmentally sustainable methods to process aerospace alloys.			
(U)				
(U)	CONGRESSIONAL ADD: National Aerospace Leadership Initiative.	19.500	15.904	0.000

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2306 Materials**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U)	In FY 2007: Supported aerospace R&D, fortified U.S.-based manufacturing supply chain, and strengthen aerospace equipment manufacturers' R&D.			
(U)	In FY 2008: Continue to support aerospace R&D, fortif U.S.-based manufacturing supply chain, and strengthened aerospace equipment manufacturers' R&D.			
(U)	In FY 2009: Not Applicable.			
(U)	CONGRESSIONAL ADD: Hybrid Materials for Thermal Management in Thin Films and Bulk Composites.	0.000	1.591	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Conduct research to develop advanced aeronautical structural members, sheathing, and coatings having longer service life.			
(U)	In FY 2009: Not Applicable.			
(U)	Total Cost	39.054	37.436	25.681

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 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 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0603211F, Aerospace Structures.									
(U) PE 0708011F, Industrial Preparedness.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2306 Materials**

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2307 Fluid Mechanics	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2307 Fluid Mechanics	13.576	14.366	18.486	20.812	22.467	23.080	23.199	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Investigate and characterize complex phenomena in supersonic, hypersonic, boundary layers, and turbulent flows to enable and optimize the design of air and space vehicles and flight control systems.	5.285	5.492	8.744

(U) In FY 2007: Characterized and modeled critical phenomena required to predict and control unsteady, vortex-dominated flows and to develop rapid maneuver controls on UAVs. Validated current models and explored higher-fidelity models for unsteady aerodynamics of complex, hypersonic flows to include boundary layer effects, shock-dominated flows (engine inlets), and nonequilibrium effects. Developed control strategy models for mitigating excessive heat transfer and unsteadiness in hypersonic flows and for abating the effects of highly separated flows.

(U) In FY 2008: Characterize and model fundamental phenomena of 3-D high-speed boundary layers to facilitate prediction and control of laminar-turbulent transition and the onset of severe heating rates in high-speed systems. Extend applicability and capability to handle complex flows of high-fidelity, unsteady numerical models for shock-dominated flows, and nonequilibrium effects. Continue development of control strategy models for mitigating excessive heat transfer and unsteadiness in hypersonic flows and for abating the effects of highly separated flows.

(U) In FY 2009: Extend efforts to characterize and model fundamental phenomena of high-speed boundary laminar-turbulent transition to include interactions between multiple instability modes. Validate high-fidelity, unsteady numerical simulation methodologies for shock-dominated flows and nonequilibrium effects. Extend strategies for control of excessive heat transfer, unsteadiness, and separation in hypersonic flows to reduce severe local loads on systems. Explore interactions between severe phenomena in aerothermodynamic environment and high-temperature vehicle materials with the goal of reducing thermal protection system complexity and increasing

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	performance to improve reusability, sustainability, efficiency, and turn time of hypersonic and space-access vehicles.			
(U)				
(U)	MAJOR THRUST: Expand fundamental knowledge of unsteady flows in integrated theoretical, experimental, and computational efforts. Study complex rotating and internal flow phenomena related to turbomachinery and jet engine applications with an emphasis on flow control approaches.	6.342	6.489	9.742
(U)	In FY 2007: Evaluated advanced flow control coupling mechanisms in complex, turbulent flows, including transient phenomena and time accurate simulation techniques. Evaluated reduced order, closed-loop flow control mechanisms on unsteady flow of complex geometries and jet engines. Developed large eddy simulation techniques to include heat transfer and fluid flow coupling in preliminary simulations of film cooling flows. Evaluated hybrid computational techniques for accurately modeling turbulent flows. Evaluated coupling between aerodynamic and structural mistuning mechanisms in multiple blade row interactions tied to high cycle fatigue failures. Developed predictive tools for unsteady flow control approaches using sensors and actuators for harsh environments.			
(U)	In FY 2008: Further develop reduced order, closed-loop flow control mechanisms on unsteady flows of complex geometries and jet engines. Investigate new applications of flow control techniques to improve jet engine integration and efficiency for a wider range of flight operating conditions. Develop tools for predicting and controlling unsteady, vortex-dominated flows on unmanned aerial vehicles (UAVs). Explore and develop innovative techniques for improving convective heat transfer at all flow scales to enhance thermal management of subsonic and supersonic flight systems.			
(U)	In FY 2009: Continue to develop reduced order, closed-loop flow control mechanisms on unsteady flows of complex geometries and jet engines and identify specific applications to transition technology. Characterize and model promising applications of flow control techniques to improve jet engine integration and efficiency for a wider range of flight operating conditions. Validate tools for predicting and controlling unsteady, vortex-dominated flows on UAVs. Continue to develop innovative techniques for improving convective heat transfer at all flow scales to enhance thermal management of subsonic and supersonic flight systems.			
(U)				
(U)	CONGRESSIONAL ADD: Development and Validation of Advanced Design Technologies for Hypersonic Research (National Hypersonic Research Center)	1.949	2.385	0.000
(U)	In FY 2007: Conducted research on experimental and numerical simulation to characterize and develop predictive numerical methods for physical phenomena associated with hypersonics.			
(U)	In FY 2008: Continue research on experimental and numerical simulation to characterize and develop predictive numerical methods for physical phenomena associated with hypersonics.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2307 Fluid Mechanics**

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

	FY 2007	FY 2008	FY 2009
(U) In FY 2009: Not Applicable.			
(U)			
(U) Total Cost	13.576	14.366	18.486

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602201F, Aerospace Flight Dynamics.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0603211F, Aerospace Structures.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: **February 2008**

BUDGET ACTIVITY: **01 Basic Research**

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

PROJECT NUMBER AND TITLE: **2308 Propulsion**

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2308 Propulsion	20.499	21.144	25.432	25.732	26.956	27.431	27.847	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Research and model space propulsion and power in the areas of chemistry, electronics, miniaturization, and contamination/signature.	8.786	9.054	11.695

(U) In FY 2007: Conducted research on plasma-based, charged droplet based, and beamed-energy thrusters. Investigated pulsed detonation rocket engines and other new engine concepts. Examined methods to predict and suppress combustion instabilities. Investigated high altitude plumes signature and contamination. Investigated magnetohydrodynamic (MHD) flow control to optimize scramjet flow path performance. Investigated lightweight superconducting magnet capability for MHD flow control of advanced engines.

(U) In FY 2008: Conduct studies of small satellite, microsatellite, and nanosatellite propulsion and investigate plasma dynamics in these thrusters. Evaluate methods to predict and suppress combustion instabilities under supercritical conditions, and develop research models that can be incorporated into the design codes. Develop novel diagnostic techniques for characterization of combustion instabilities in high pressure, harsh, optically thick environments. Continue to investigate high altitude plumes signature and contamination. Investigate alternate launch systems using electromagnetic forces as a rail-gun or coil-gun. Conduct research to enable revolutionary designs of satellite systems that can achieve the simultaneous objectives of increasing payload and/or time in orbit and increasing mission flexibility and scope.

(U) In FY 2009: Continue studies of small satellite, microsatellite, and nanosatellite propulsion and investigate plasma dynamics in these thrusters. Continue to investigate high altitude plumes signature and contamination. Continue investigating alternate launch systems using electromagnetic forces. Conduct fundamental component and system level research that leads to the introduction of novel multi-use technologies and concepts in order to achieve

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2308 Propulsion

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	multi-functional satellite architectures and the development of highly efficient power generation/recovery systems (e.g., micro electro-mechanical turbines and nano-structured thermoelectric units) deeply integrated with thermal management or spacecraft structure. Enhance novel diagnostic techniques for characterization of combustion instabilities in high pressure, harsh, optically thick environments.			
(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. Starting in FY 2008, conduct basic research in support of a higher Air Force priority Energy Conservation -Assured Fuels Initiative to identify and develop technologies that enable the use of domestic fuel sources for military energy needs.	8.886	11.096	13.737
(U)	In FY 2007: Improved laser diagnostic measurement capabilities in the characterization of turbulent reacting flows. Investigated molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions. Incorporated prediction methodologies, which are both quantitatively accurate and computationally tractable, into turbulent combustion models. Enhanced scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Investigated fuels and propellants that are more energetic, environmentally benign, and less sensitive to accidental detonations. Formulated strategies for using alternate hydrocarbon fuels based on the incorporation of detailed chemistry models into large eddy simulations.			
(U)	In FY 2008: Continue improving laser diagnostic measurement capabilities, investigations of molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions, and prediction methodologies, which are both quantitatively accurate and computationally tractable, for turbulent combustion models. Further enhance scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Expand strategies for using alternate hydrocarbon fuels based on the incorporation of detailed chemistry and transport models through surrogate fuel representations. Conduct research to provide fuel-flexible energy conversion technology in support of the Energy Conservation-Assured Fuels Initiative.			
(U)	In FY 2009: Continue improving laser diagnostic measurement capabilities, investigations of molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions, and prediction methodologies, which are both quantitatively accurate and computationally tractable, for turbulent combustion models. Continue exploring the scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Exploit strategies for using alternate hydrocarbon fuels by inserting reduced fuel representations into comprehensive combustion models such as large eddy simulations. In			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2308 Propulsion

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

		FY 2007	FY 2008	FY 2009
	support of the Energy Conservation-Assured Fuels Initiative, identify surrogate fuels that will represent the behavior of current and future alternative fuels through chemically simplified chemical compounds that retain the energy conversion characteristics of the base fuels.			
(U)				
(U)	CONGRESSIONAL ADD: Coal-Based Jet Fuels.	2.827	0.000	0.000
(U)	In FY 2007: Conducted research to produce coal-based jet fuels. Assess military utility and suitability of this fuel.			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Coal Transformation Laboratory.	0.000	0.994	0.000
(U)	In FY 2007: Not Applicable.			
(U)	In FY 2008: Conducted research to produce domestic sources of biofuels and coal-based fuels.			
(U)	In FY 2009: Not Applicable.			
(U)	Total Cost	20.499	21.144	25.432

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602102F, Materials.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0603211F, Aerospace Structures.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2311 Information Sciences	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2311 Information Sciences	26.008	25.257	31.640	32.512	36.241	38.062	39.045	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2007, this project is renamed from "Space and Information Sciences" to "Information Sciences." In FY 2008, Space Environment efforts were moved to Project 2301 in this PE to more accurately align basic research efforts in Physics.

(U) A. Mission Description and Budget Item Justification

Information sciences basic research generates fundamental knowledge and understanding to support critical Air Force capabilities in information superiority, precision targeting (or strike), and improved battlespace awareness. Areas of research focus are (1) access to disparate data and information, (2) information fusion and distribution, and (3) conversion of information into knowledge to support decision making. The data, fusion engines, and command and control functions reside on interlocking systems connected by networks leading to a system of systems architecture. Areas of research underpinning these team-focused, network-enabled systems are those in networks and communications, software, information management, and human-system interactions. Complementing these overall focus areas, research is occurring in the following areas: information operations network, software, and system architectures; information fusion; information forensics; communications and signals and control of large systems.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(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: In FY 2008, efforts previously in this Major Thrust were moved into Project 2301 in this PE to more accurately align basic research efforts in Physics.	8.893	0.000	0.000

(U) In FY 2007: Expanded 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. Developed space-based sensor technology. Explored the solar interior as a complex system through advanced modeling techniques. Explored 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. Developed understanding of fundamental processes of energetic particle scattering in the near-Earth environment to support protection of space assets. Investigated solar processes and energetic events, the solar wind, and fundamental processes in the magnetosphere, ionosphere, and thermosphere. Searched for understanding of fundamental processes controlling space plasma to improve ability to forecast near-Earth space environment. Analyzed data from DoD surveillance and the Communications/Navigation Outage Forecasting System-Solar Mass Ejection Imager (C/NOFS-SMEI) satellites to improve remote sensing of interplanetary space. Initiated research to investigate the neutral winds above 150 kilometers. Employed all-sky imaging to study of ionospheric plasma phenomena and

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Information Sciences**

(U) **B. Accomplishments/Planned Program ($ in Millions)**	FY 2007	FY 2008	FY 2009
develop techniques to quantify these observations.			
(U) In FY 2008: Not Applicable.			
(U) In FY 2009: Not Applicable.			
(U)			
(U) MAJOR THRUST: Explore basic mechanisms to realize gains in innovative transformational communications technologies, thereby enabling the Air Force to enhance its dominance communications using the space medium.	0.993	0.994	1.000
(U) In FY 2007: Investigated innovative methods for optical communications such as partial coherence, polarization modulation, and liquid crystal spatial modification techniques. Explored the basic mechanisms of dual polarization antennas for space applications.			
(U) In FY 2008: Refine the details of the investigation that partially coherent laser beams are less disturbed by passage through turbulent atmospheres than their classically coherent counterparts. Pursue the design of solid state lasers which can emit such partially coherent beams. Continue to investigate the possibility that the long distance stability of polarization states can be exploited to communicate digitized messages.			
(U) In FY 2009: Contiune to study and refine results of selected solid state partially coherent laser designs together with the propagation of partially coherent laser beams through surrogate turbulent media. Monitor the polarization states to verify the predicted long distance stability.			
(U)			
(U) MAJOR THRUST: Investigate signal communications, surveillance, and targeting for increased awareness and improved command and control for the battlefield commander. Efforts include research in linear operator theory, generalized functions and probability, harmonic methods, and asymptotic expansions.	4.667	5.378	7.055
(U) In FY 2007: Explored data fusion science to enable rapid data conversion across multiple bands into graphical and conceptualized information. Studied methodologies for evaluating the performance of new wireless mobile, networked communications systems. Studied and assessed technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery. Investigated the hybrid radio-frequency/free-space optical paradigm and refined the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. Developed ultra-wide band transmission technology for hyperspectral and other diverse data.			
(U) In FY 2008: Focus on integrating results in distributed navigation, geo-location, and interactive telemetry to improve the collecting and interpreting of battlespace information, with emphasis placed on dealing with diverse, changing warfare scenarios. Continue to study methodologies for evaluating the performance of new wireless mobile, networked communications systems. Continue study and assessment of technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery. Continue to investigate the hybrid			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Information Sciences**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	radio-frequency/free-space optical paradigm and refine the parameters of other innovative technologies to attain ultra-fast, reliable information exchange.			
(U)	In FY 2009: Study navigation approaches such as "optical flow field" to improve understanding of the foundation for over-arching methodologies that integrate sensing data collected by distributed, inter-communicating networks of sensor resources. Continue to develop ultra-wide band transmission technology for hyper-spectral and other diverse data. Continue to study methodologies for evaluating the performance of new wireless mobile, networked communications systems. Continue study and assessment of technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery.			
(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, and information fusion.	11.455	18.885	23.585
(U)	In FY 2007: Developed information operations science techniques to exploit information intensive systems and networks. Developed information fusion science to provide deep, adaptive, expert decision support. Exploited quantum and bio-computing techniques and algorithms to allow enhanced tracking, recognition, and characterization to improve situational awareness, command and control, and security. Investigated first principles of software system architectures including characteristic property metrics and begin development of automatic software architecture analysis tools.			
(U)	In FY 2008: Significantly increase investigation of first principles of software system, network, and information system architectures including characteristic properties and metrics, and begin development of automatic software architecture analysis tools. Add research on brilliant software agents and other techniques for information operations, knowledge mining, and to improve situational awareness and command and control. Continue evolving information operations science techniques to exploit information intensive systems and networks. Further develop information fusion science to provide deep, adaptive, expert decision support.			
(U)	In FY 2009: Continue to increase emphasis on investigating first principles of software system architectures including characteristic properties and metrics, and begin development of automatic software architecture analysis tools. Continue research on brilliant software agents and other techniques for information operations, knowledge mining, and to improve situational awareness and command and control. Continue to develop information operations science techniques to exploit information intensive systems and networks. Continue developing information fusion science to provide deep, adaptive, expert decision support.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2311 Information Sciences**

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

	FY 2007	FY 2008	FY 2009
(U)	0.000	0.000	0.000
(U) Total Cost	26.008	25.257	31.640

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602500F, Multi-Disciplinary Space Technology.									
(U) PE 0602601F, Space Technology.									
(U) PE 0602702F, Command, Control, and Communications.									
(U) PE 0603410F, Space System Environmental Interactions Technology.									
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2312 Biological Sciences	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2312 Biological Sciences	9.682	10.332	10.473	10.601	10.444	10.230	10.120	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(U) MAJOR THRUST: Characterize, understand, predict, control, and engineer biomolecular responses induced in organisms by chemical and physical agents of Air Force significance, such as alternate synthetic jet fuels, nano-energetic materials, and directed energy. Identify, characterize, and engineer novel enzymatic properties that enable photosynthetic microbes to use light energy for the renewable generation of hydrogen fuel from water. Explore biomolecular profiles and hormetic mechanisms involved in the positive stimulatory (rather than the negative inhibitory) biological responses induced by low-doses of toxic agents and investigate the implications of such low-dose positive stimulation in inducing a protective state in tissue that is resistant to subsequent high-dose toxicity.	5.534	5.836	5.906

(U) In FY 2007: Validated biokinetics models used to predict the fuel constituent levels in tissues following dermal and pulmonary exposures to fuel mixtures. Applied methodologies for profiling and modeling the biomolecular responses induced by the interactions of directed energy and nano-energetic materials with biological systems. Utilized biocatalysis techniques and genetic engineering principles to elicit the water-based generation of fuel-cell hydrogen by photosynthetic microbes. Investigated the biomolecular profiles for underlying mechanisms associated with positive stimulatory or "hormetic" responses of biological systems exposed to very low-levels of known toxic

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2312 Biological Sciences

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
substances and hazardous radiation.			
(U) In FY 2008: Refine whole animal biokinetic models predicting tissue disposition of fuel components based on iterative experimental input derived from laboratory animal exposures and analyses. Begin to apply newly developed methodologies to acquire in vitro and in vivo data from biological systems exposed to nano-scale structures possessing varying physical and chemical properties. By using recently improved methodologies, begin the molecular profiling and characterization of biological systems responding to high and low doses of directed energy generated from laser and microwave sources. Continue bio-prospecting for hydrogen-generating microbes and begin bio-engineering and directed-evolution experiments aimed at enhancing the photosynthetic flow of electrons and protons to the hydrogen-generating enzyme. Continue to utilize state-of-the-art tools and techniques to explore, collect, and analyze date with regard to low-dose chemical and radiation exposure effects and the molecular pathways and profiles mediating the responses to the exposures.			
(U) In FY 2009: Begin to integrate individual computational models characterizing multi-component fuel deposition in lung and absorption through skin into animal biokinetic models for predicting whole animal disposition of single fuel components. Continue to collect data from biological systems exposed to nano-materials and begin to develop a data base of responses for future predictive modeling studies based on physico-chemical properties of various nanostructures. Continue collecting directed energy dose-response data and begin bioinformatics analyses to identify unique biomolecular profiles responding to specific levels of radiant exposure. Continue bio-prospecting, bio-engineering, and directed-evolution approaches to the generation of hydrogen fuel by photosynthetic microbes and begin metabolic engineering research to identify and eliminate pathways that drain unnecessary energy equivalents away from the hydrogen-generating apparatus. Continue utilizing state-of-the-art tools and techniques to explore, collect, and analyze date with regard to low-dose chemical and radiation exposure effects and the molecular pathways and profiles mediating the responses to the exposures.			
(U)			
(U) MAJOR THRUST: Explore biomimetics, biomaterials, and biointerfacial sciences to enable development of novel sensors, engineering processes, and mechanisms, and the synthesis of novel materials, as well as to research new sensor modalities, explore surface-mediated process, and delve into extreme environmental conditions. Research in biophysical mechanisms will look to discover and understand basic biological mechanisms that could be used to either harden or repair bio-based devices or can utilize complex, impure biofuels for compact power.	4.148	4.496	4.567
(U) In FY 2007: Investigated, evaluated, modeled, and mimicked biological processes and designs for future applications in near-ambient temperature sensing devices, and added predator avoidance and new prey detection schemes as future technology areas. Probed and manipulated biochromophores and biophotoluminescent			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2312 Biological Sciences

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

	FY 2007	FY 2008	FY 2009
characteristics in microbial and protein-based biosystems for applications to military sensor systems. Exploited biomaterial and biointerfacial sciences to control cellular systems to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications. Researched surface mediated cellular differentiation as a new sensor modality. Expanded into extremophile research to access biosynthetic pathways not achievable with room temperature organisms.			
(U) In FY 2008: Initiate work on manipulating materials to mimic the desirable properties found in skin for maintenance, self-healing, and repair. Continue to investigate predator avoidance and new prey detection schemes as future technology areas. Further probe and manipulate biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Continue to exploit biomaterial and biointerfacial sciences to control cellular systems to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications. Research surface mediated cellular differentiation as a new sensor modality. Continue investigations in extremophile research to access biosynthetic pathways and materials not achievable with room temperature organisms. Continue work in biophysical mechanisms to discover and understand the basic underlying biological mechanism that could be used to either harden or repair bio-based devices or can utilize complex, impure biofuels for compact power.			
(U) In FY 2009: Continue work on manipulating materials to mimic the desirable properties found in skin for maintenance, self-healing and repair. Expand investigating predator avoidance and new prey detection schemes as future technology areas. Further probe and manipulate biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Continue to exploit biomaterial and biointerfacial sciences to control cellular systems to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications. Research surface mediated cellular differentiation as a new sensor modality. Continue investigations in extremophile research to access biosynthetic pathways and materials not achievable with room temperature organisms. Continue work in biophysical mechanisms to discover and understand the basic underlying biological mechanism that could be used to either harden or repair bio-based devices or can utilize complex, impure biofuels for compact power.			
(U) Total Cost	9.682	10.332	10.473

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602202F, Human									

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2312 Biological Sciences**

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

Effectiveness Applied Research.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0602602F, Conventional Munitions.

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

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2008
BUDGET ACTIVITY: 01 Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE: 2313 Human Performance	

Cost ($ in Millions)	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
2313 Human Performance	12.161	11.052	15.255	18.065	19.220	19.538	21.299	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

Human performance basic research seeks the fundamental knowledge needed to understand, measure, and optimize human capabilities critical to Air Force operations. Within this project, the special areas of scientific interest include Sensory Systems, Cognition and Decision, Homeostatic and Circadian Regulation of Human Performance, and Socio-Cultural Modeling. In all areas, experimental efforts are coordinated with mathematical or computational modeling. Air Force sensory research emphasizes human auditory capabilities, including 3D spatial hearing, multi-talker communication, speech intelligibility, and informational masking. Cognitive research emphasizes decision optimization in complex, dynamic tasks, including coordinated decision-making performed by networked, multi-person teams. Also aligned with Air Force cognitive research are efforts to determine how best to promote robust, reliable decision-making through information-processing algorithms for fusion, automation, and intelligent signal processing. Modeling efforts include cultural factors that may affect behavior in adversarial decision-making. The Air Force reliance on sustained human performance during trans-meridian operations and night operations motivates basic research efforts to predict and mitigate cognitive impairments from extended wake and much higher than normal workload periods.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(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.	5.244	5.367	6.468

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

(U) In FY 2008: Continue empirical research with mathematical and computational modeling in spatial audition, speech perception, and hearing protection. Prepare new understanding of speech recognition and acoustic noise for transition to hearing protection technologies. Exploit multi-sensory integration methods and novel biological sensing mechanisms. Continue to probe biophysical mechanisms responsible for fatigue, including models of sleep/wake dynamics. Shift emphasis from acute to chronic sleep deprivation in order to predict specific consequences in the performance of individual warfighters. Refine models showing effects of ultrashort laser pulse on the eye (laser flash blindness).

(U) In FY 2009: Engage new research methods to characterize requirements for optimal speech communication,

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **2313 Human Performance**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	including modulation representation and filtering. Develop data, models, and algorithms to minimize informational masking in speech signals and in spatial audio displays. To inform the design of new hearing protection systems, develop and test theoretical models for bone- and tissue-conducted cochlear excitation in high-noise environments. To improve the ability to understand and forecast cognitive impairments during continuous high workload conditions, employ new genomic and brain-monitoring methods to identify biomarkers for individual susceptibility. Devise new, physiologically accurate quantitative models to elucidate mechanisms of sleep/wake timing, homeostatic recovery, and re-entrainment to circadian phase shifts (e.g., "jet lag").			
(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. Discover dynamic models of attitudes and beliefs that drive adaptive decision-making of interacting non-cooperative groups.	5.162	5.685	8.787
(U)	In FY 2007: Developed quantitative models of individual and team information processing and decision-making including applications to systems to improve the speed and accuracy of networked teams. Employed progress on modeling individual and team training for the development of training systems optimized for specific individuals, teams, and applications. Assessed mechanisms for continuous learning and automated, diagnostic mentoring of individuals. Developed models of symbolic spatial-imaginal processing. Explored measures to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload.			
(U)	In FY 2008: Continue to refine quantitative models of individual and team information processing and decision-making for application to systems for improving speed and accuracy of decisions networked teams. Employ progress on modeling individual and team training for the development of training systems optimized for specific individuals, teams, and applications. Assess mechanisms for continuous learning and automated, diagnostic mentoring of individuals to enable human and machine collaboration. Continue exploring measures to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload. Increase cognitive process modeling to include socio-cultural influences in competitive or non-cooperative environments for successful Airmen response to and prediction of adversary actions.			
(U)	In FY 2009: Specific research objectives include the development of mathematical and computational models to characterize important aspects of human cognitive performance in situations applicable to Air Force operational environments. The goal is to optimize human information-processing, problem-solving, and decision making, both for individual war fighters and for networked, collaborative teams. Research will probe human inference and reasoning under uncertainty, algorithms for information integration and fusion, and new approaches to ensure robust			

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY 01 Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT NUMBER AND TITLE 2313 Human Performance

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

		FY 2007	FY 2008	FY 2009
	decision-making under continuous, extended duty and under rapidly changing, adversarial conditions. Continue to refine agent-based modeling and game theory, to include socio-cultural influences in competitive or non-cooperative environments for successful response to and prediction of adversary actions. New efforts will promote cross-disciplinary contributions from brain science, operations research, network theory, and computer science.			
(U)				
(U)	CONGRESSIONAL ADD: Virtual Teleoperations for Unmanned Aerial Vehicles.	1.755	0.000	0.000
(U)	In FY 2007: Conducted research on virtual reality technology to allow a single operator to simultaneously monitor and control multiple unmanned aerial vehicles remotely.			
(U)	In FY 2008: Not Applicable.			
(U)	In FY 2009: Not Applicable.			
(U)	Total Cost	12.161	11.052	15.255

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) 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 2008
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 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total
4113	External Research Programs Interface	8.376	11.946	9.835	9.813	9.599	9.938	10.319	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

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

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
(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.	4.354	4.766	5.435

(U) In FY 2007: Provided centralized cooperation expertise and supported international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Capitalized on foreign investments by influencing and acquiring world-class scientific research. Established and maintained access to technical briefs and publications on unique foreign research and research capabilities. Supported international visits of high-level DoD delegations and provided primary interface to coordinate international participation among DoD organizations. Assisted in Air Force fiscal commitments to NATO-affiliated research institutes.

(U) In FY 2008: Continue to provide centralized cooperation expertise and support international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Continue to capitalize on foreign investments by influencing and acquiring world-class scientific research. Continue to seek and maintain access to technical briefs and publications on unique foreign research and research capabilities. Continue to support international visits of high-level DoD delegations and provide primary interface to coordinate international participation among DoD organizations. Continue to assist in Air Force fiscal commitments to NATO-affiliated research institutes.

(U) In FY 2009: Continue to provide centralized cooperation expertise and support international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Continue to capitalize on foreign investments by influencing and acquiring world-class scientific research. Continue to seek and

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **4113 External Research Programs Interface**

	B. Accomplishments/Planned Program ($ in Millions)	FY 2007	FY 2008	FY 2009
	maintain access to technical briefs and publications on unique foreign research and research capabilities. Continue to support international visits of high-level DoD delegations and provide primary interface to coordinate international participation among DoD organizations. Continue to assist in Air Force fiscal commitments to NATO-affiliated research institutes.			
(U)				
(U)	MAJOR THRUST: Strengthen science, mathematics, and engineering research and educational infrastructure in the U.S., thereby strengthening Air Force technical capabilities. Assure the Air Force of continuing availability of superior technical talent and forge Air Force Research Laboratory relationships with premiere scientists.	4.022	7.180	4.400
(U)	In FY 2007: Supported science, mathematics, and engineering research and educational outreach programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Increased 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 2008: Continue to support science, mathematics, and engineering research and educational outreach programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Increase awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research.			
(U)	In FY 2009: Continue to support science, mathematics, and engineering research and educational outreach programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Increase awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research. Note: $3.0M erroneously placed in this effort for Science Board support moved out of this program in FY 2009 and out.			
(U)	Total Cost	8.376	11.946	9.835

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

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0601103D, University Research Initiative.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2008
BUDGET ACTIVITY **01 Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT NUMBER AND TITLE **4113 External Research Programs Interface**

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

(U) PE 0602102F, Materials.
(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.