Exhibit R-2, PB 2010 Air Force RDT&E Budget Item Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research					R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	275.207	313.845	321.028						Continuing	Continuing
612301: Physics	47.502	48.851	46.971						Continuing	Continuing
612302: Solid Mechanics and Structures	16.074	17.978	19.747						Continuing	Continuing
612303: Chemistry	32.089	38.125	39.118						Continuing	Continuing
612304: Mathematics and Computing Sciences	23.019	30.500	33.345						Continuing	Continuing
612305: Electronics	31.489	39.179	40.568						Continuing	Continuing
612306: Materials	36.069	25.609	29.442						Continuing	Continuing
612307: Fluid Mechanics	13.652	20.429	24.213						Continuing	Continuing
612308: Propulsion	20.145	26.159	31.447						Continuing	Continuing
612311: Information Sciences	24.081	31.551	46.436						Continuing	Continuing
612312: Biological Sciences	9.736	10.444	0.000						Continuing	Continuing
612313: Human Performance	10.569	15.213	0.000						Continuing	Continuing
614113: External Research Programs Interface	10.782	9.807	9.741						Continuing	Continuing

Note

Note: In FY 2010, research efforts in Projects 2312 and 2313 moved to Projects 2306, 2307, 2308, and 2311 in this PE to more accurately align them to the Projects they support.

Exhibit R-2, PB 2010 Air Force RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	**R-1 ITEM NOMENCLATURE** PE 0601102F Defense Research Sciences

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. This program is in Budget Activity 1, Basic Research, because it funds scientific study and experimentation.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	288.601	309.926	322.878	
Current BES/President's Budget	275.207	313.845	325.912	
Total Adjustments	-13.394	3.919	0.000	
Congressional Program Reductions	0.000	-0.027		
Congressional Rescissions	0.000	-0.854		
Total Congressional Increases	0.000	4.800		
Total Reprogrammings	-6.826	0.000		
SBIR/STTR Transfer	-6.568	0.000		

Change Summary Explanation

Note: In FY 2009, 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 million for Nanotechnology Based Biosensors and Biothreat Detectors, $0.7 million for UNR (University of Nevada-Reno)-Millimeter Wave-Based Fatigue Countermeasure Technology, $1.6million 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.

C. Performance Metrics
(U) Under Development.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612301	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612301: Physics	47.502	48.851	46.971						Continuing	Continuing

Note

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.

A. Mission Description and Budget Item Justification

Physics basic research seeks to enable revolutionary advances in, and expand the fundamental knowledge of 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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
MAJOR THRUST: Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and multi-aperture adaptive optics. In FY 2008: Studied mechanical, optical, and laser properties of ceramic materials as a function of material and preparation parameters. Investigated novel index, gain, and doping profiles for high power, high beam, quality ceramic lasing. Studied means for efficiently producing and making available quasi-phase matched semiconductor crystals for tunable high energy lasing. Studied 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. 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, and 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.	9.041	10.609	10.778	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2010: Extend high energy solid-state laser research into new materials and materials processing procedures to increase the average power and tunability range of ceramic lasers. Study novel optical fiber geometries to achieve single mode operation in large core area, thereby allowing high power operation. Study novel techniques for alleviating deleterious nonlinear optical effects in high power, single mode fiber lasers, and novel means to couple such lasers for very high powers.				
MAJOR THRUST: Explore high-energy, electro-energetic device concepts and manipulate atomic and molecular properties, atomic collision processes, and atomic, molecular, ionic, and radiation interactions to improve explosives and fuels, advance directed energy systems, enhance surveillance, provide superior communications, and improve precision navigation. In FY 2008: Explored 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. Explored the possibility of tailor-making materials using the results of research in the overlap between atomic physics and condensed matter physics. Studied new concepts for high-power, high-frequency electromagnetic radiation sources. Studied quantum physics effects relating to the emission of electrons from surfaces. Examined the application of Chaos Theory effects to raise fundamental limits on electrical energy storage density. Studied the seamless integration of magnetohydrodynamic and particle-in-cell modeling algorithms to better capture the detailed physics of high power microwave sources. 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	12.635	14.216	13.857	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2010: Continue to investigate compact sources of pulsed radiation in the regimes of high-frequency (e.g., X-rays and beyond) and very high peak-power sources of both electromagnetic and particle radiation (e.g., electrons). For precision navigation applications, continue to study compact atom interferometry. Explore the possibility of achieving precision beyond the standard quantum limit (i.e., the shot noise limit) by generating and utilizing entangled states of atoms. Continue to develop frequency comb techniques for precision sensing and metrology, as well as cold and ultracold atom based techniques. Explore properties of ultracold molecules for precision measurement applications. Investigate slow and stopped light processes for improving optical communication. Continue to explore the possibility of tailor-making materials, including novel states of matter, using the results of research in the overlap between atomic physics and condensed matter physics. Move from microfabrication to nanofabrication methodologies to achieve higher frequencies in compact, high-power electromagnetic radiation sources. Exploit new knowledge of quantum-level electron emission physics to create new generation of low work function field-emission (cold) high current density cathodes. Enhance new simulation code algorithms to full 3-dimensional hybrid modeling of high power microwave sources.				
MAJOR THRUST: Advance technologies for space sensors, imaging, identification and tracking methods, and effective space situational awareness. In FY 2008: Developed theoretical approaches to the surveillance and identification of space objects from both the ground and from space. Continued to study propagation of electromagnetic energy, image formation, image recovery, and information content maximization from both ground-based and space-based sensors. Investigated methods to mitigate environmental effects on sensors and sensor systems. Investigated atmospheric density forecast models to improve satellite orbit determination and tracking. 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.	4.493	5.871	5.948	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. In FY 2010: Investigate new sensing modalities to improve resolution and precision limits of ground-based and space-based surveillance of space objects. Continue study of spectral, polarimetric, and temporal signatures of space objects to identify unresolved space objects. Investigate physics involved in active imaging techniques. Investigate inclusion of fundamental processes of the solar-terrestrial system into physics-based models to predict atmospheric density and increase precision of satellite orbit prediction and precision tracking.					
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, and better space-based communications and quantifying the risks to space systems. In FY 2008: Began 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. Investigated fundamental plasma modeling theory using new grid-free, full kinetic modeling techniques and developed novel techniques to include electromagnetism. Continued development of ground-based and space-based sensor technology for remote sensing and in situ measurement of space weather conditions. Continued 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. Continued 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. Continued to analyze data from DoD surveillance satellites to improve remote sensing of interplanetary space. Maintained focused research to investigate the neutral densities and winds above 150 kilometers. In FY 2009: Study 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		4.722	6.110	6.202	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
astronomy techniques for remote sensing the space environment. Continued search for understanding of fundamental physics and processes controlling solar, heliospheric, magnetospheric ionospheric, and thermospheric environments. 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. 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. In FY 2010: Continue developing of methods to sense atmospheric and ionospheric quantities using small, inexpensive satellites. Continue the study of space plasmas using grid-free modeling techniques. Investigate fundamental processes to enable the forecasting of the near-Earth space environment. Investigate coupling and dependencies of the various environments from the sun through the Earth's atmosphere that would enable the understanding of energy flow throughout the various regions. Investigate plasma instabilities in the equatorial and polar regions that degrade communication and navigation signals. Expand the study of neutral densities and winds that affect satellite drag.					
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 operational settings. In FY 2008: Continued 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. Continued to develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media with an emphasis on designs for 100KW laser weapons. Continued to investigate the dynamics of		8.501	10.045	10.186	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
transonic/supersonic/hypersonic platforms with an emphasis on stores release. Modeled 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. Studied the design of reconfigurable warheads through suitable timing/placement of micro-detonators together with effects of metal particle inclusions. Improved methods for recognizing and tracking targets 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. Pursued the design of electromagnetic sources which, with the help of novel materials, can transmit optimized waveforms for a variety of surveillance purposes. 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. Study electromagnetic sources interaction with novel materials for transmitting optimized waveforms for surveillance. In FY 2010: Study the susceptibility of electronic circuits exposed to electromagnetic waveforms. Continue to pursue an understanding of the propagation of ultra-short laser pulses through the atmosphere. Exploit terahertz radiation, and components of laser-guided bombs or ladar when cloud cover is present. Increase researching electromagnetic waveforms from the perspective of dispersive media (foliage, clouds, buildings, airplane boundary layers). Objective is to improve spatial resolution of objects obscured by such media.				
CONGRESSIONAL ADD: Chabot Space and Science Center.		0.763	0.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2008: Developed new science programs for K-12 students, teachers, and the general public. In FY 2009: Not Applicable. In FY 2010: Not Applicable.				
CONGRESSIONAL ADD: High Energy Laser for Detection, Inspection and Non-Destructive Testing. In FY 2008: Conducted laser technology research to support multiple applications, including inspection of military hardware and equipment flaws, and detecting weapons hidden in cargo ships. In FY 2009: Not Applicable. In FY 2010: Not Applicable.	4.771	0.000	0.000	
CONGRESSIONAL ADD: Nanotechnology Based Biosensors and Bio-Threat Detectors In FY 2008: Researched how 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. In FY 2009: Not Applicable. In FY 2010: Not Applicable.	1.908	0.000	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
CONGRESSIONAL ADD: UNR - Millimeter Wave-Based Fatigue Countermeasure Technology. In FY 2008: Developed a novel device based on millimeter wave technology that will serve as a skeletal muscle fatigue countermeasure for use in the battlefield. In FY 2009: Not Applicable. In FY 2010: Not Applicable.	0.668	0.000	0.000	
CONGRESSIONAL ADD: Center for Microplasma Science and Technology (CMST) In FY 2008: Not Applicable. In FY 2009: Create a National Center for the microplasma research field. In FY 2010: Not Applicable.	0.000	2.000	0.000	

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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602204F/ Aerospace Sensors.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602605F/ Directed Energy Technology.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612302	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612302: Solid Mechanics and Structures	16.074	17.978	19.747						Continuing	Continuing

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. 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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2008: Expanded research in the area of multifunctional composite systems with structurally integrated antenna functions of broad bandwidth and improved structural endurance. Continued research in the areas of diagnostics, prognostics, autonomics, self-healing, thermal management, energy harvesting/storage, and micro-/nano-mechanics enabled safer and more durable aerospace structures with improved performance characteristics. Further developed the fundamental knowledge required to design and manufacture multifunctional aerospace material systems and devices and to predict their performance and structural integrity. Developed and exploited methods that combined information technology and multi-scale modeling in the design of new material systems and devices. In FY 2009: Continue research in the area of multifunctional 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 improved performance characteristics. Further develop the fundamental knowledge required	7.622	8.578	7.561	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. In FY 2010: Expand research in the area of multifunctional materials and microsystems for reconfigurable structures allowing shape change and property tuning. Continue research in the area of multifunctional 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 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.					
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). In FY 2008: Developed novel theoretical and experimental methods for constructing and modeling morphing structures that broaden system operational capabilities. Continued development of novel actuation devices and materials for a variety of Air Force applications to aircraft and space structures. Studied the science issues related to the introduction into new structural concepts of the novel materials developed under the advanced materials programs. Used the knowledge acquired about the novel materials to develop new aerospace structural concepts. Developed an integrated approach to structural systems lifetime prognosis. Continued the development of structural health monitoring sensors and techniques towards an integrated vehicle-wide approach. Consolidated the exploration of mechanical and dynamic behavior of micro-/nano-scale structures. Expanded the investigation of nonlinear phenomena associated with the structural deformation and aero-elastic instabilities and limit-cycle vibration to include novel structural concepts.		8.452	9.400	12.186	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. Continue the development of structural health monitoring sensors and techniques towards an integrated vehicle-wide approach. Expand the understanding of mechanical and dynamic behavior of micro-/nano-scale structures to 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. In FY 2010: Search for unprecedented new and revolutionary flight structure concepts that will permit broader operational capabilities, a faster reconfigurable ability, and more affordable accelerated fabrication; this search will include morphing aircraft structures. Investigate novel actuation devices and materials for Air Force aircraft and space structural applications. Expand scientific knowledge related to new structures of the novel materials developed under the advanced materials programs. Expand development of structural health monitoring sensors and techniques towards an integrated vehicle health monitoring and operational capability prognosis. Understand a risk-based approach to structural systems lifetime prognosis and reliability. Expand understanding of mechanical and dynamic behavior of flight structures under extreme environments (e.g., intense vibration, nonlinear structural dynamics, unsteady aero-thermo-elastic effects on flight structure, and directed energy) with objective of enhancing operational survivability and mission success.				

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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602201F/ Aerospace Flight Dynamics.	0.000	0.000							Continuing	Continuing
PE 0602202F/ Human Effectiveness Applied Research.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0603211F/ Aerospace Structures.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612303	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612303: Chemistry	32.089	38.125	39.118						Continuing	Continuing

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.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. In FY 2008: Developed new theoretical and computational methods to enhance capabilities to predict and simulate properties of chemicals and materials of interest to the Air Force. Continued to develop new experimental methods to advance understanding of reactivity and energy flow in molecules for applications to signatures, battle space awareness, propellants, munitions, and laser systems. Explored ability to understand and control catalysis and plasmonic structures to enhance propulsion and energetic applications and sensitive detection of target compounds. 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, battle space awareness, propellants, munitions, and laser systems. Continue to	13.790	16.402	16.543	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612303	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
develop novel applications of catalysis and plasmonic structures for applications to propulsion, energetics, and sensing. Explore new concepts for closed-cycle hybrid chemical lasers. In FY 2010: Advance the development of experimental and theoretical methods to understand and control chemical reactivity and energy in molecular systems. Develop the understanding of catalytic mechanisms in systems that can improve energy utilization in propulsion applications. Explore synthetic methods and computational screening procedures to streamline the production of novel propellants. Investigate methods for producing energetic metastable species and analyzing their lifetimes. Explore the mechanisms of processes induced by plasmonic structures and its impact on chemical processes. Perform experiments and theoretical analysis to provide benchmarks for models of chemistry in the space environment. Investigate novel approaches for high-power hybrid electric-chemical lasers.					
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. In FY 2008: Explored power generation and power storage for warfighters based on improved polymers for solar cells and fuel cells applications. Continued to explore photonic polymers and conductive polymers for communications and detections. Investigated 3-D displays based on photorefractive polymers. Polymers with controlled dielectric permittivity and magnetic permeability were explored for advanced radar antenna applications. Controlled growth mechanisms of carbon single wall nanotubes were investigated. 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.		9.689	12.221	12.698	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2010: Further exploit advances in nanotechnology to improve properties of magneto-dielectric materials for antenna substrate applications. Explore hybrid materials approach to enhance optical limiting behavior and optical filtering response for broadband laser protection applications. Improve charge mobility of organic transistors to enable higher speed responses for Air Force applications.				
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. In FY 2008: Developed 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. Continued to investigate phenomena at surface interfaces, including friction and wear, lubrication, corrosion, and degradation. Explored novel approaches to corrosion prevention, particularly multi-disciplinary efforts that combine corrosion initiation, detection, and lifetime prediction. Continued tribological investigations that focus on bridging the fundamental gap between macro- and nano-scale mechanisms, including heat transfer, chemical reactivity, and atmospheric effects. Continued to investigate nano-scale surface structures for power applications. 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 nano-composite lubricants that provide function over a wide variety of extreme environments, including space. In FY 2010: Continue to develop theoretical and predictive methods for the fundamental understanding of the structure and reactivity of surfaces and interfaces, particularly under non-equilibrium conditions. Continue to investigate phenomena at surfaces and interfaces, including the fundamental mechanisms of friction and wear, lubrication, corrosion, material degradation in extreme environments, and thermal transport. Develop methods for understanding and controlling interfacial chemistry in the creation of complex materials, including	7.089	9.502	9.877	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
nano-composite lubricants that provide function over a wide variety of extreme environments. Develop instrumentation and methodologies capable of examining surface chemistry and kinetics with high spatial resolution.					
CONGRESSIONAL ADD: Fully-Integrated Solar-Powered Interior Lighting Technology. In FY 2008: Continued to conduct research to integrate solar-energy-generating photovoltaic materials and light-emitting organic materials for self-contained lighting systems for combat locations. In FY 2009: Not Applicable. In FY 2010: Not Applicable.		1.521	0.000	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602602F/ Conventional Munitions.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612304	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612304: Mathematics and Computing Sciences	23.019	30.500	33.345						Continuing	Continuing

Note

Note:

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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 systems' control and dynamics necessitate resource increases in this major thrust. In FY 2008: Investigated emerging novel approaches for cooperative control systems in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unattended aerial vehicles (UAVs), and constellations of small satellites. Conducted additional research for teams of micro air vehicles operating at various altitudes in complex environments to execute assigned missions with variable operator intervention. Advanced control methodologies and modeling to improve non-equilibrium behavior of complex, unsteady fluid systems with applications for combustion, materials processing, and agile autonomous flight. Continued to advance image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive vehicle testing. Advanced methods for design and analysis of bio-inspired sensing systems, controls, and computational systems. Continued development of algorithms for control of and over dynamic, large-scale networks. Investigated theory and algorithms for specification, design, verification, and validation of	11.376	15.564	16.820	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
distributed embedded systems. Researched potential devices to exploit nonlinear dynamic phenomena with a focus on detection, classification, and control systems for use in urban combat environments. 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. In FY 2010: 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 with an emphasis on heterogeneous agents and mixed human-robot interactions. Expand additional research for teams of micro air vehicles operating at various altitudes in complex environments to execute assigned missions with variable operator intervention to include adaptive control and machine learning. Develop control methodologies to improve non-equilibrium behavior of complex, nonlinear systems. Continue to advance image processing and sensor technologies for use in UAV controllers and smart munitions to include target tracking and ownship state estimation. Develop mathematical control theoretic models that capture the robust, nonlinear, hybrid dynamics of microbiological systems. 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 control systems.					
		10.695	14.936	16.525	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2008: Continued 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 battle space information management. Approaches included both rigorous analytical tools and meta heuristic searches. Continued 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 included aerodynamics for various flight regimes, high power microwaves, material design, and structural mechanics. Continued 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. Enhanced uncertainty quantification based on rigorous error analysis in non-linear models of aerodynamic flows and structural failure predictions. Developed mathematical models that dynamically evolved and dealt with operational data that were incomplete, uncertain, conflicting, or overlapping. 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 battle space 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.				

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2010: Continue to develop theoretically rigorous and computationally effective mathematical methods for solving large and complex problems in logistics, system diagnostics/prognostics, air mobility contingencies, engineering design, target tracking, and strategic/tactical planning for battle space information management. Meta heuristic searches are combined with rigorous methods and emphasis is placed on those for which provable bounds are shown. Place emphasis on development of innovative mathematical and numerical algorithms that enhance modeling and simulation capabilities in understanding and forecasting of complex physical phenomena and design and control of systems of interest to the Air Force. The application areas of interest include non-equilibrium plasma, non-steady aerodynamics for various flight regimes, material design, and structural mechanics. Focus on numerical algorithms that include multi-scale and multi-physics approaches with particular emphasis on convergence, error analysis and adaptability. Increase emphasis on development of algorithms for efficient and robust multidisciplinary design and optimization as well as understanding and quantifying the effects of uncertainties in computational models.				
CONGRESSIONAL ADD: Process Integrated Mechanism for Human-Computer Collaboration and Coordination. In FY 2008: Developed 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. In FY 2009: Not Applicable. In FY 2010: Not Applicable.	0.948	0.000	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences	PROJECT NUMBER 612304

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602201F/ Aerospace Flight Dynamics.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602602F/ Conventional Munitions.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control, and Communications.	0.000	0.000							Continuing	Continuing
PE 0603789F/ C3I Advanced Development.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612305	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612305: Electronics	31.489	39.179	40.568						Continuing	Continuing

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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 multispectral 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. In FY 2008: Investigated novel reconfigurable multifunctional 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. Investigated innovative multispectral 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 novelheteromaterial interfacing and interconnect schemes, and biologically-based detection processes.	7.437	9.366	9.821	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
In FY 2009: Continue investigating novel innovative reconfigurable multifunctional electronic materials, material bandgap and defect-band tuning concepts, phenomenology-based detection mechanisms, novel hetero-material interfacing and interconnect schemes, and novel nano-science 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. In FY 2010: Investigate novel methods for achieving integrated multi-mode electromagnetic spectra detection utilizing spatial, spectral, polarimetric, radiometric, phase, and temporal imaging and non-imaging detection and discrimination techniques, to include adaptive reconfigurable 'pixel' and/or detector element approaches spanning multiple-modes, and in one or more ultraviolet-infrared bands; biologically inspired detection processes and concepts will also be considered. Possible novel detector structures will include, but not limited to, integrated monolithic and/or hybrid approaches utilizing homogeneous and/or heterogeneous semiconductor and oxide material structures, potentially enabled by 0D, 1D, and/or 2D quantum-based structures. Additionally, bulk and nano-structure based electronic defect engineering physics will be studied to determine opportunities for modifying electronic band structure that critically affects photon absorption and carrier transport properties.					
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 battle space. In FY 2008: Continued to investigate nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Continued to explore nanoelectronics, nanophotonics, spintronics and other advanced optoelectronic and electronic materials and devices for lower power consumption, high-efficiency wavelength-diverse lasers, and high-sensitivity detectors. Furthered the examination of advanced optical memory technologies for enhanced data storage, including		13.608	15.717	15.968	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
negative index of refraction metastructures. Investigated technologies for robust monolithic and miniature terahertz frequency spectrum devices and quantum cascade lasers. Continued to investigate communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments. 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, and high-sensitivity 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 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. In FY 2010: Further support research activities to better understand the fundamental nature of multi-ferroic alloys and composite materials for potential applicability to spin-gain devices, dynamic magnetic field detection for RF and microwave applications, and very high efficiency and compact piezoelectric AC to AC and DC to DC transformers. Continue to investigate meta-materials, phase-change and state-change semiconducting and dielectric materials for exploitation in reconfigurable logic, memory, and dynamic analog devices and systems. Further investigate silicon photonics as a mechanism for all optical fiber device signal and power interconnect. Further support research activities in the development of interconnectable photonic crystal modules so that integrated, all-optical photonic crystal logic and control systems can be subsequently developed as a transition from basic research.				
MAJOR THRUST: Exploit advances in nanotechnology to support multi-spectral detection technology, chip-scale optical networks, and compact power.	5.023	6.839	7.161	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2008: Further developed and refined techniques to control growth of self-assembled quantum structures and connections to these structures for multi-spectral image processing. Tested functionalities of structural materials and improved growth methods. Continued 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. Continued exploring nanophotonic concepts for information processing components and systems. 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. In FY 2010: Develop revolutionary infrared sensors with new functionality that would greatly limit the complexity, cost, and size of conventional imaging systems. Create mid-infrared detectors with nanoscale-patterned metallic photonic crystal structures supporting frequency-specific optical resonances that achieve dramatic improvement in the conversion efficiency of detectors. Investigate the fundamental science, materials, processes, and novel device architectures for surface plasmon-based, CMOS-compatible, optical elements, with focus on ultracompact, robust, and highly efficient photonic networks that are optimally suited for insertion into mobile military platforms. Exploit nanoscience to further understand and improve solar cells, fuel cells, thermoelectrics, and supercapacitors, by examining approaches such as quantum dots, nanowires, nanocrystals, nanotubes, nanomembranes, and non-traditional materials.				
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.	5.421	7.257	7.618	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2008: Recent success in increasing current-carrying properties of high-temperature superconducting short sections of tape was exploited to increase those properties in longer lengths and attempts were made to reduce eddy-current loses. Microwave properties of high-temperature superconductors were given added emphasis because of recent progress in reducing losses at high frequencies. The goal was to provide thin-film superconducting material that could provide improved radar systems and compact communications systems. The search for practical even higher-temperature superconductors was continued. Efforts to create true 3-D negative index material at frequencies from microwave to infrared and visible were augmented. The search for higher-temperature, high-energy-product magnetic materials was continued using innovative nanomaterial technology. Using carbon nanotubes and other nanomaterials, new compact architectures were created to further miniaturize devices for signal processing, memory storage, and sensing. 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. In FY 2010: The coordinated program to discover more useful, more economical superconductors for power and electronic applications will have been put in place, and progress toward identifying promising materials will set in motion new efforts in physics, chemistry and materials science. New concepts in superconducting electronics will be tested using both magnesium diboride and yttrium-barium-copper-oxide superconducting films. Research will continue to find routes to make nanoscale ordered structures that will open the use of metamaterials to the optical and infrared part of the electromagnetic spectrum. At microwave frequencies metamaterials will be formed to produce sub-wavelength imaging. Demonstration of denser memory elements will be accomplished using crossbar architecture in contact with standard CMOS circuitry.				

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602204F/ Aerospace Sensors.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control, and Communications.	0.000	0.000							Continuing	Continuing
PE 0603203F/ Advanced Aerospace Sensors.	0.000	0.000							Continuing	Continuing
PE 0603789F/ C3I Advanced Development.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612306	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612306: Materials	36.069	25.609	29.442						Continuing	Continuing

Note

Note: In FY 2010, Natural Materials and Systems efforts from Project 2312 in this PE moved to this Project to more accurately align basic research efforts in Materials.

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 aerospace 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. Basic research is also conducted in natural materials and systems to exploit unique properties and products for use in the development of advanced weapon technologies. Research is conducted to mimic the natural detection systems of organisms at the molecular level for use in developing novel man-made sensors. Research in natural materials focuses on using existing organisms or bioengineered organisms to manufacture new materials, or using the organisms themselves as materials. The primary areas investigated by this project are ceramics, non-metallic hybrid composites, metallic materials, and natural materials and systems.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2008: Continued to optimize the design of multi-functional structural ceramic materials to enable structurally enhanced smart systems for application in extreme environments. Exploited new approaches in improving the thermal and mechanical stability of oxide ceramic composites for aircraft and engine applications. Further developed high-temperature resistant and joining methodologies for lightweight ceramic materials. Continued to develop innovative concepts for developing higher temperature and more damage-tolerant	9.135	12.351	12.255	

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APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612306	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
organic, inorganic, and polymer matrix composites. Continued to exploit the use of nanomaterials and nanocomposites in aerospace structures. In FY 2009: Continue optimizing the design of multi-functional structural ceramic materials to enable structurally enhanced smart systems for application in extreme environments. Expand the development of new approaches in improving the thermal and mechanical stability of ceramic and metallic composites for aerospace applications. Explore the role of the operational environment on the mechanisms of failure in hybrid materials. Expand the development of innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Continue to exploit the use of nanomaterials and nanocomposites in aerospace structures. In FY 2010: Explore the connectivity of molecular scale modeling and micromechanics modeling to link the influence of constituents' properties to properties of fiber reinforced composites, ceramic matrix composites, and metallic composites. Interfacial properties of hybrid materials will be explored and their influence on component durability will be investigated. Damage initiation due to oxidation of high temperature polymer matrix composites will be modeled.					
MAJOR THRUST: Research metallic materials and identify relationships between structures including microstructures, processing, properties, and performance to develop durable metallic systems for advanced engines and aerospace structural applications. In FY 2008: Continued investigating metallic materials for sustainable use in structural applications and advanced engines. Investigated nano-laminates and nano-composites for aerospace armor and small air-vehicle structures. Explored the interaction between chemistry and mechanics in surfaces and interfaces of these nanoscale structures. Explored the processing and development of multifunctional structural metals for power systems and space applications. Capitalized on advances in multi-scale modeling to study the response of aerospace alloys exposed to corrosive environments and cyclical loading. Developed an informatics process exploiting disparate sources of materials' properties data derived from modeling and experimentation. Explored the fundamental science of friction and thermal effects during friction stir processing.		10.078	13.258	12.704	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612306	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
In FY 2009: Continue to 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. Study development 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. In FY 2010: Expand the investigation of complex laminates for aerospace materials to include understanding of failure mechanisms within these novel systems. Expand the development and verification of multi-scale equilibrium models to study the response of the material in a non-equilibrium environment. Refine the development of the informatics tools to accelerate the discovery of novel materials. Evolve the research on the fundamental science of friction and thermal effects during friction stir processing to focus on the role of the interface within metallic composites. Explore novel and alternative mechanisms to rapidly accelerate the processing and certification of advanced high temperature aerospace materials.					
MAJOR THRUST: Explore mimetics, natural materials, and natural/synthetic interfaces 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 physical mechanisms in nature will look to discover and understand basic natural mechanisms that could be used to either harden or repair natural materials-based devices and systems. Note: In FY 2010, these efforts moved to this Project from Project 2312 in this PE to more accurately align basic research efforts in Materials. In FY 2008: Not Applicable.		0.000	0.000	4.483	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2009: Not Applicable. In FY 2010: Continue manipulating materials to mimic the properties found in autonomous materials for sensing, maintenance, self-healing, and repair. Expand investigating predator avoidance and new prey detection schemes as future technology areas. Further probe and manipulate chromophores and photoluminescent characteristics in natural systems for applications to military sensor systems. Continue to exploit natural materials and natural/synthetic interfaces to: 1) control natural systems, 2) synthesize novel materials, 3) evaluate sensors, and 4) elucidate nanotechnology applications. Research natural materials' extension into new electronic and photonic systems by utilizing the self-assembly of these materials into unique electronic and optical architectures for ISR applications. Investigate natural systems in order to develop new synthetic avenues to produce unique material properties and systems. Continue investigations in extremophile research to access synthetic pathways and materials not achievable under standard conditions. Continue work in physical mechanisms in nature to discover and understand the basic underlying natural mechanism that could be used to either harden or repair natural materials-based devices.				
CONGRESSIONAL ADD: National Aerospace Leadership Initiative. In FY 2008: Continued to support aerospace R&D, fortify US-based manufacturing supply chain, and strengthen aerospace equipment manufacturers' R&D. In FY 2009: Not Applicable. In FY 2010: Not Applicable.	15.323	0.000	0.000	
CONGRESSIONAL ADD: Hybrid Materials for Thermal Management in Thin Films and Bulk Composites. In FY 2008: Conducted research to develop advanced aeronautical structural members, sheathing, and coatings having longer service life.	1.533	0.000	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2009: Not Applicable. In FY 2010: Not Applicable.				

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602201F/ Aerospace Flight Dynamics.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0603211F/ Aerospace Structures.	0.000	0.000							Continuing	Continuing
PE 0708011F/ Industrial Preparedness.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612307	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612307: Fluid Mechanics	13.652	20.429	24.213						Continuing	Continuing

Note

Note: In FY 2010, Natural Flight Control and Navigation efforts from Project 2313 in this PE moved to this Project to more accurately align basic research efforts in Fluid Mechanics.

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. Vehicle control principles based upon natural flight sensory and sensorimotor systems applicable to small unattended aerial vehicles (UAVs) and ultraslow flight are also examined. 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.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. In FY 2008: Characterized and modeled 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. Extended applicability and capability to handle complex flows of high-fidelity, unsteady numerical models for shock-dominated flows, and non-equilibrium effects. Continued development of control strategy models for mitigating excessive heat transfer and unsteadiness in hypersonic flows and for abating the effects of highly separated flows.	5.219	8.744	9.836	

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APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612307	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 non-equilibrium 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 performance to improve reusability, sustainability, efficiency, and turn time of hypersonic and space-access vehicles. In FY 2010: Characterize and model fundamental phenomena of high-speed boundary laminar-turbulent transition to include interactions between multiple instability modes and realistic surface conditions including roughness. Validate high-fidelity, unsteady numerical simulation methodologies for shock-dominated flows including non-equilibrium effects, laminar-turbulent transition and automated grid refinement. Continue exploration of strategies for control of excessive heat transfer, unsteadiness, and separation in hypersonic flows to reduce severe local loads on systems. Characterize and model interactions between severe phenomena in aerothermodynamic environment and high-temperature vehicle materials with the goal of reducing thermal protection system complexity and increasing system performance.					
MAJOR THRUST: Expand fundamental knowledge of unsteady flows in integrated theoretical, experimental, and computational efforts. Study complex flow phenomena related to unsteady phenomena and coupled fluid-structure interactions with an emphasis on flow control approaches. In FY 2008: Further developed reduced order, closed-loop flow control mechanisms on unsteady flows of complex geometries and jet engines. Investigated new applications of flow control techniques to improve jet engine integration and efficiency for a wider range of flight operating conditions. Developed tools for predicting and controlling unsteady, vortex-dominated flows on UAVs. Explored and developed innovative techniques for improving convective heat transfer at all flow scales to enhance thermal management of subsonic and supersonic flight systems.		6.167	9.685	10.689	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2010: Explore reduced order, closed-loop flow control mechanisms on unsteady flows of complex geometries and flexible structures and identify canonical problems. Characterize and model promising applications of flow control techniques to optimize fluid-structure interactions and aerodynamic efficiency for a wider range of flight operating conditions. Validate tools for predicting and controlling unsteady, vortex-dominated flows on UAVs. Explore scientific issues related to multidisciplinary simulation of unsteady fluid-structure interactions.				
MAJOR THRUST: Research novel sensing and control mechanisms applicable to small UAVs and low Reynolds Number flight regimes. Expand fundamental knowledge of natural flight control and navigation mechanisms for which analogues do not yet exist in conventional engineered flight. Note: In FY 2010, these efforts moved to this Project from Project 2313 in this PE to more accurately align basic research efforts in Fluid Mechanics. In FY 2008: Not Applicable. In FY 2009: Not Applicable. In FY 2010: Characterize and model sensor-effector systems for natural flight control, target pursuit, and spatial navigation, with emphasis on robust agility at low Reynolds Numbers. Study sensory information processing mechanisms, including multi-modal sensing, to understand autonomous spatial orientation and optimal flight path guidance. Characterize closed-loop control mechanisms to optimize performance capabilities of flexible airfoils, e.g., with respect to sensing and handling of airflow disturbances, Coriolis forces, and wing loading.	0.000	0.000	3.688	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Develop and test neuromorphic emulations to enable adoption in engineered technology for autonomous or semi-autonomous air vehicles.				
CONGRESSIONAL ADD: Development and Validation of Advanced Design Technologies for Hypersonic Research (National Hypersonic Research Center). In FY 2008: Continued research on experimental and numerical simulation to characterize and develop predictive numerical methods for physical phenomena associated with hypersonics. In FY 2009: Continue research on numerical simulation to characterize and develop predictive methods for physical phenomena associated with hypersonics. In FY 2010: Not Applicable.	2.266	2.000	0.000	

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602201F/ Aerospace Flight Dynamics.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0603211F/ Aerospace Structures.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences	PROJECT NUMBER 612307

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612308	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612308: Propulsion	20.145	26.159	31.447						Continuing	Continuing

Note

Note: In FY 2010, Bioenergy and Catalysis efforts from Project 2312 in this PE moved to this Project to more accurately align basic research efforts in Propulsion.

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. As a newly emerging research direction within this project, bioenergy and catalysis will investigate the economical production of renewable biofuels for airbreathing engines and will explore biocatalysis for compact power applications.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
MAJOR THRUST: Research and model space propulsion and power in the areas of chemistry, electronics, miniaturization, and contamination/signature. In FY 2008: Conducted studies of small satellite, microsatellite, and nanosatellite propulsion and investigated plasma dynamics in these thrusters. Evaluated methods to predict and suppress combustion instabilities under supercritical conditions, and developed research models that can be incorporated into the design codes. Developed novel diagnostic techniques for characterization of combustion instabilities in high pressure, harsh, optically thick environments. Continued to investigate high altitude plumes signature and contamination. Investigated alternate launch systems using electromagnetic forces as a rail-gun or coil-gun. Conducted 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.	8.627	11.695	11.809	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612308	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 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. In FY 2010: Continue to research high altitude plume signature and contamination, including ice formation and optical scattering in geosynchronous orbits. Continue investigating alternate launch systems using electromagnetic forces and beamed energy. Investigate electrothermal materials in plasma propulsion to achieve regenerative power, thereby resulting in higher efficiencies and lower waste heat in satellites. Investigate novel energetic propellants for space propulsion to achieve cryogenic propellant performance with non-cryogenic systems. Introduce nano-energetics in liquid or gel propellants to increase specific impulse in liquid propulsion systems, and investigate various spray techniques for these novel propellant systems. Further enhance novel diagnostic techniques for characterization of combustion instabilities in high pressure, harsh, optically thick environments.					
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. Note: 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. In FY 2008: Continue improving laser diagnostic measurement capabilities, investigations of molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical		10.571	13.664	14.375	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612308	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
thermodynamic conditions, and prediction methodologies, which were both quantitatively accurate and computationally tractable, for turbulent combustion models. Further enhanced scientific bases for how plasmas were used to improve aerodynamic characteristics and propulsive efficiencies. Expanded strategies for using alternate hydrocarbon fuels based on the incorporation of detailed chemistry and transport models through surrogate fuel representations. Conducted research to provide fuel-flexible energy conversion technology in support of the Energy Conservation-Assured Fuels Initiative. 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 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. In FY 2010: 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. Initiate research on the coupling between plasma chemistry and fuel combustion chemistry to understand ignition and combustion enhancement by plasmas. Continue exploitation of strategies for using alternate hydrocarbon fuels by inserting reduced fuel representations into comprehensive combustion models such as large eddy simulations. In support of the Energy Conservation-Assured Fuels Initiative, initiate studies of novel propulsion system design based on alternative fuel properties to achieve optimization with respect to performance, environmental impact, cost, and assured supply.					
		0.000	0.000	5.263	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
MAJOR THRUST: Identify, characterize, and bioengineer photosynthetic and/or non-photosynthetic microorganisms for the macro-scale production of renewable jet and hydrogen fuels and for the micro-scale utilization of complex, impure biofuels in the delivery of compact power. Explore the basic mechanisms that control electron transfer reactions in biological catalysts, particularly at the biotic-abiotic interface. Note: In FY 2010, these efforts moved to this Project from Project 2312 in this PE to more accurately align basic research efforts in Propulsion. In FY 2008: Not Applicable. In FY 2009: Not Applicable. In FY 2010: Continue researching the biosolar generation of hydrogen by seeking to understand and manipulate the metabolic, genetic, and biophysical mechanisms utilized by some photosynthetic microbes (algae and cyanobacteria) in generating renewable hydrogen energy. Begin researching algal oil generation as a renewable jet fuel source by bio-prospecting for unique, oil-generating strains of algae whose genes may be used to enhance the production of algal oil. Continue research on biological fuel cells that explore the biophysical and catalytic mechanisms required for efficient electron transfer between electrodes and microbial materials, enabling the future utilization of complex, impure biofuels for compact power needs.				
CONGRESSIONAL ADD: Coal Transformation Laboratory. In FY 2008: Conducted research to produce domestic sources of biofuels and coal-based fuels. In FY 2009: Conduct basic research in the area of coal-to-liquids fuels, with focus on addressing the barriers that inhibit rapid commercialization of coal to liquid technologies. In FY 2010: Not Applicable.	0.947	0.800	0.000	

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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0603211F/ Aerospace Structures.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612311	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612311: Information Sciences	24.081	31.551	46.436						Continuing	Continuing

Note

In FY 2010, efforts in building and testing mathematical descriptions of cognitive decision-making moved from Project 2313 in this PE to this Project to more accurately align basic research efforts in Information Services.

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 battle space 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. Information Sciences also derive mathematical models and computational algorithms designed to optimize information intelligently and problem-solving under adverse conditions, including sustained operations, non-cooperative environments, and multi-interactive command and control.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
MAJOR THRUST: Explore basic mechanisms to realize gains in innovative transformational communications technologies, thereby enabling the AF to enhance its dominance communications using the space medium. Note: In FY 2010, this effort merged with the major thrust immediately following to more accurately align with other signal communications efforts. In FY 2008: Refined the details of the investigation that partially coherent laser beams are less disturbed by passage through turbulent atmospheres than their classically coherent counterparts. Pursued the design of solid state lasers which can emit such partially coherent beams. Continued to investigate the possibility that the long distance stability of polarization states can be exploited to communicate digitized messages.	0.948	1.000	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009	
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences		PROJECT NUMBER 612311

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2009: Continue 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. In FY 2010: Not Applicable.				
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, asymptotic expansions, and transformational communications technologies. In FY 2008: Focused 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. Continued to study methodologies for evaluating the performance of new wireless mobile, networked communications systems. Continued study and assessment of technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery. Continued to investigate the hybrid radio-frequency/free-space optical paradigm and refine the parameters of other innovative technologies to attain ultra-fast, reliable information exchange. 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. In FY 2010: Further 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. Move toward an evaluative assessment of practicality of free-space optical communication based on reduced or variable beam	5.127	7.055	6.488	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612311	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
coherence. Conduct research in compressive sensing and image reconstruction to effect fusion of diverse sensors under multi-modal regime and data from sensor networks and countermeasures. Continue assessment of technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery.					
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. In FY 2008: Significantly increased the investigation of first principles of software system, network, and information system architectures including characteristic properties and metrics, and began development of automatic software architecture analysis tools. Added research on brilliant software agents and other techniques for information operations, knowledge mining, and to improve situational awareness and command and control. Continued evolving information operations science techniques to exploit information intensive systems and networks. Further developed information fusion science to provide deep, adaptive, expert decision support. 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. In FY 2010: Focus studies on developing software-intensive systems that take into account the deep interaction between humans and computers. Begin information operations research on attack attribution and hardware/software interface security, and continue research on covert channel discovery. Develop fundamental mathematical methods for the description of local, global, and dynamic phenomena in networks		18.006	23.496	26.746	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
and the assurance of the associated protocols. Develop techniques that enable integration of information and processes on networked systems in order to achieve high levels of situation awareness and response.					
MAJOR THRUST: Evaluate fundamental mechanisms and build mathematical descriptions of cognitive decision-making, including adaptation to non-cooperative interactions. Test mathematical models to predict and compensate for information-processing vulnerability. Conduct fundamental research on informational masking and signal intelligibility in communication networks. Note: In FY 2010, these efforts moved to this Project from Project 2313 in this PE to more accurately align basic research efforts in Information Sciences. In FY 2008: Not Applicable. In FY 2009: Not Applicable. In FY 2010: Investigate high-order cognitive processes critical for decision-making and problem-solving, with emphasis on the challenges of sustained operations in environments that require efficient operations under risk, uncertainty, high workload, and fatigue. Elucidate brain mechanisms that may inform computational approaches to information analysis, including mathematical representations of coupled neural oscillation, modulation filtering, and compressive sampling. Seek deeper scientific insight into principles of adaptive intelligence. Develop new approaches to optimize problem-solving in dynamic environments, with emphasis on decision strategies for adversarial, multi-dimensional, and multi-cultural conflict. Develop the basic research foundation, using computational and modeling approaches, to understand and anticipate competitive and cooperative interactions among decision-makers in a cross-cultural context.		0.000	0.000	13.202	

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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control, and Communications.	0.000	0.000							Continuing	Continuing
PE 0603410F/ Space System Environmental Interactions Technology.	0.000	0.000							Continuing	Continuing
PE 0603500F/ Multi-Disciplinary Advanced Development Space Technology.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 612312	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612312: Biological Sciences	9.736	10.444	0.000						Continuing	Continuing

Note

Note: In FY 2010, efforts were moved from this Project to Projects 2306 and 2308 within this PE to more accurately align basic research efforts in the Materials and Propulsion disciplines, respectively.

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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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	5.499	5.877	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
subsequent high-dose toxicity. Note: In FY 2010, efforts moved from this Project to Project 2308 within this PE to more accurately align basic research efforts in Propulsion. In FY 2008: Refined whole animal biokinetic models predicting tissue disposition of fuel components based on iterative experimental input derived from laboratory animal exposures and analyses. Began 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, began the molecular profiling and characterization of biological systems responding to high and low doses of directed energy generated from laser and microwave sources. Continued 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. Continued 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. 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. In FY2010: Not Applicable.				

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. Note: In FY 2010, efforts moved from this Project to Project 2306 within this PE to more accurately align basic research efforts in Materials. In FY 2008: Initiated work on manipulating materials to mimic the desirable properties found in skin for maintenance, self-healing, and repair. Continued to investigate predator avoidance and new prey detection schemes as future technology areas. Further probed and manipulated biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems. Continued to exploit 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. Continued investigations in extremophile research to access biosynthetic pathways and materials not achievable with room temperature organisms. Continued 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. In FY 2009: Continue work on manipulating materials to mimic the desireable properties found in skin for maintenance, self-healing, and repair. Expand investigating predator avoidance andnew 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 that could be used to either harden or repari bio-based devices or can utilize complex, impure biofuels for compact power.	4.237	4.567	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2010: Not Applicable.				

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602202F/ Human Effectiveness Applied Research.	0.000	0.000							Continuing	Continuing
PE 0602204F/ Aerospace Sensors.	0.000	0.000							Continuing	Continuing
PE 0602602F/ Conventional Munitions.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control, and Communication.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification								DATE: May 2009		
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COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
612313: Human Performance	10.569	15.213	0.000						Continuing	Continuing

Note

Note: In FY 2010, efforts will move from this Project to Projects 2307 and 2311 within this PE to more accurately align basic research efforts in the Fluid Dynamics and Information Science disciplines, respectively.

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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. Note: In FY 2010, efforts moved from this Project to Project 2307 within this PE to more accurately align basic research efforts in Fluid Dynamics. In FY 2008: Continued empirical research with mathematical and computational modeling in spatial audition, speech perception, and hearing protection. Prepared new understanding of speech recognition and acoustic noise for transition to hearing protection technologies. Exploited multi-sensory integration methods and	5.132	6.468	0.000	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences			PROJECT NUMBER 612313	
B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
novel biological sensing mechanisms. Continued to probe biophysical mechanisms responsible for fatigue, including models of sleep/wake dynamics. Shifted emphasis from acute to chronic sleep deprivation in order to predict specific consequences in the performance of individual warfighters. Refined models showing effects of ultrashort laser pulse on the eye (laser flash blindness). In FY 2009: Engage new research methods to characterize requirements for optimal speech communication, 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"). In FY 2010: Not Applicable.					
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. Note: In FY 2010, efforts will move from this Project to Project 2311 within this PE to more accurately align basic research efforts in Information Sciences. In FY 2008: Continued 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. 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 to enable human and machine collaboration. Continued exploring measures		5.437	8.745	0.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
to avert/mitigate human error and optimize decision making under conditions of uncertainty and information overload. Increased cognitive process modeling to include socio-cultural influences in competitive or non-cooperative environments for successful Airmen response to and prediction of adversary actions. 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 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. In FY 2010: Not Applicable.				

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0602202F/ Human Effectiveness Applied Research.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control, and Communication.	0.000	0.000							Continuing	Continuing

D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences					PROJECT NUMBER 614113	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
614113: External Research Programs Interface	10.782	9.807	9.741						Continuing	Continuing

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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. In FY 2008: Continued to provide centralized cooperation expertise and support international technology liaison missions in order to identify and maintain awareness of foreign science and technology developments. Continued to capitalize on foreign investments by influencing and acquiring world-class scientific research. Continued to seek and maintain access to technical briefs and publications on unique foreign research capabilities. Continued to support international visits of high-level DoD delegations and provide primary interface to coordinate international participation among DoD organizations. Continued to assist in Air Force fiscal commitments to NATO-affiliated research institutes. 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.	4.302	5.407	5.319	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009			
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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Continue to seek and maintain access to technical briefs and publications on unique foreign 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. In FY 2010: 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 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.					
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. In FY 2008: Continued 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. 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. 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.		6.480	4.400	4.422	

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
In FY 2010: 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.				

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Activity Not Provided/ Related Activities:	0.000	0.000							Continuing	Continuing
PE 0601103D/ University Research Initiative.	0.000	0.000							Continuing	Continuing
PE 0602102F/ Materials.	0.000	0.000							Continuing	Continuing
PE 0602201F/ Aerospace Flight Dynamics.	0.000	0.000							Continuing	Continuing
PE 0602202F/ Human Effectiveness Applied Research.	0.000	0.000							Continuing	Continuing
PE 0602203F/ Aerospace Propulsion.	0.000	0.000							Continuing	Continuing
PE 0602204F/ Aerospace Avionics.	0.000	0.000							Continuing	Continuing
PE 0602269F/ Hypersonic Technology Program.	0.000	0.000							Continuing	Continuing
PE 0602500F/ Multi-Disciplinary Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602601F/ Space Technology.	0.000	0.000							Continuing	Continuing
PE 0602602F/ Conventional Munitions.	0.000	0.000							Continuing	Continuing
PE 0602702F/ Command, Control and Communication.	0.000	0.000							Continuing	Continuing

Exhibit R-2a, PB 2010 Air Force RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 3600 - Research, Development, Test & Evaluation, Air Force/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601102F Defense Research Sciences	PROJECT NUMBER 614113

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.