Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force										DATE: February 2010	
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 2009 Actual**	**FY 2010 Estimate**	**FY 2011 Base Estimate**	**FY 2011 OCO Estimate**	**FY 2011 Total Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	299.830	328.471	350.978	0.000	350.978	339.007	338.984	355.955	373.683	Continuing	Continuing
612301: *Physics*	46.896	48.370	50.470	0.000	50.470	47.648	47.498	49.872	52.379	Continuing	Continuing
612302: *Solid Mechanics and Structures*	16.921	19.666	20.683	0.000	20.683	19.663	18.848	19.955	20.903	Continuing	Continuing
612303: *Chemistry*	36.584	38.957	41.587	0.000	41.587	40.207	38.953	40.459	42.500	Continuing	Continuing
612304: *Mathematics and Computing Sciences*	28.707	33.208	37.697	0.000	37.697	36.221	37.258	39.215	41.193	Continuing	Continuing
612305: *Electronics*	36.876	40.401	45.066	0.000	45.066	43.056	42.368	44.526	46.763	Continuing	Continuing
612306: *Materials*	24.104	29.321	32.040	0.000	32.040	31.134	30.964	32.611	34.225	Continuing	Continuing
612307: *Fluid Mechanics*	19.346	25.706	26.800	0.000	26.800	26.226	26.394	27.830	29.182	Continuing	Continuing
612308: *Propulsion*	24.669	32.115	34.022	0.000	34.022	32.772	32.599	34.335	36.057	Continuing	Continuing
612311: *Information Sciences*	29.698	51.026	53.143	0.000	53.143	52.784	54.630	57.314	60.208	Continuing	Continuing
612312: *Biological Sciences*	9.831	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
612313: *Human Performance*	14.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
614113: *External Research Programs Interface*	11.879	9.701	9.470	0.000	9.470	9.296	9.472	9.838	10.273	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.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601102F: *Defense Research Sciences*

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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	313.845	321.028	0.000	0.000	0.000
Current President's Budget	299.830	328.471	350.978	0.000	350.978
Total Adjustments	-14.015	7.443	350.978	0.000	350.978
• Congressional General Reductions		0.000			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	-1.357			
• Congressional Adds		8.800			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	-14.015	0.000	350.978	0.000	350.978

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Project: 612301: *Physics*		
Congressional Add: *Center for Microplasma Science and Technology (CMST).*	1.995	0.000
Congressional Add: *Development of Deployable Biosensors*	0.000	1.593
Congressional Add Subtotals for Project: 612301	1.995	1.593
Project: 612307: *Fluid Mechanics*		
Congressional Add: *Development and Validation of Advanced Design Technologies for Hypersonic Research (National Hypersonic Research Center).*	1.995	1.593
Congressional Add Subtotals for Project: 612307	1.995	1.593
Project: 612308: *Propulsion*		

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force	DATE: February 2010
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Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Congressional Add: *Coal Transformation Laboratory.*	0.798	0.797
Congressional Add Subtotals for Project: 612308	0.798	0.797
Project: 612311: *Information Sciences*		
Congressional Add: *Process Integrated Mechanism for Human-Computer Collaboration and Coordination*	0.000	0.797
Congressional Add: *Safeguarding End-User military Software*	0.000	3.984
Congressional Add Subtotals for Project: 612311	0.000	4.781
Congressional Add Totals for all Projects	4.788	8.764

Change Summary Explanation

Note: The FY 2010 President's Budget sumittal did not reflect FY 2011 through FY 2015 funding. A detailed explanation of changes between the two budget positions is not provided because it cannot be made in a relevant manner.

Note: In FY 2010, Congress added $0.8 million for Process Integrated Mechanism for Human-Computer Collaboration and Coordination, $4.0 million for Safeguarding End-User Military Software, $0.8 million for Coal Transformation Laboratory, $1.6 million for Technologies for Hypersonic Research, and $1.6 million for Development of Deployable Biosensors.

Note: In FY 2010, efforts moved to Project 2306 from Project 2312 in this PE to more accurately align basic research efforts in Materials.

Note: In FY 2010, efforts moved to Project 2307 from Project 2313 in this PE to more accurately align basic research efforts in Fluid Mechanics.

Note: In FY 2010, efforts moved to Project 2311 from Project 2313 in this PE to more accurately align basic research efforts in Information Sciences.

Note: In FY 2010, efforts moved from Project 2312 to Project 2308 within this PE to more accurately align basic research efforts in Propulsion.

Note: In FY 2010, efforts moved from Project 2313 to Project 2307 within this PE to more accurately align basic research efforts in Fluid Dynamics.

Note: In FY 2010, efforts will move from Project 2313 to Project 2311 within this PE to more accurately align basic research efforts in Information Sciences.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force	DATE: February 2010
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C. Performance Metrics
(U) Under Development.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612301: *Physics*	46.896	48.370	50.470	0.000	50.470	47.648	47.498	49.872	52.379	Continuing	Continuing

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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and novel bright incoherent light sources.	10.219	10.778	11.530	0.000	11.530
FY 2009 Accomplishments: In FY 2009: Investigated applications of previous research enabling large inexpensive, very bright micro-plasma array ultraviolet sources to large flexible displays, materials curing, and small laser sources. Continued to expand research on high energy, tunable, all solid-state lasers. Studied direct-write micro-systems, including onboard power sources. Applied 3-D laser write techniques in special glasses to inexpensive, flexible subsystems for space.					
FY 2010 Plans: 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612301: *Physics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Extend studies on infrared semiconductor diode lasers to increase available power, efficiency, and wavelength range at varying temperatures. Study efficient nonlinear optical techniques capable of efficiently converting the wavelength of existing lasers to mid- and long-wave infrared, while capable of handling very high average power. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Explore high-energy, electro-energetic device concepts and manipulate atomic and molecular properties, atomic collision processes, and atomic. *FY 2009 Accomplishments:* In FY 2009: Studied 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. Explored the possibility of tailor-making materials using the results of research in the overlap between atomic physics and condensed matter physics. Exploited emerging microfabrication methodologies for the realization of compact, high-frequency, high-power electromagnetic radiation sources. Studied quantum effects impacting electron emission from surfaces. Expanded chaos theory studies to raise fundamental limits on electrical energy storage density. Created new simulation codes embodying both magnetohydrodynamic and particle-in-cell algorithms to realistically model high power microwave sources. *FY 2010 Plans:* 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	13.826	13.663	14.743	0.000	14.743

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(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-D hybrid modeling of high power microwave sources. *FY 2011 Base Plans:* In FY 2011: Explore quantum states of light and atoms, squeezed or entangled, for advancing precision sensing and metrology beyond the standard quantum limit, i.e., the shot noise limit. Continue to explore frequency comb techniques and ultracold atoms and molecules for precision measurement applications. Explore robust quantum information processing with ultracold molecules. Continue to study quantum-engineering in novel states of matter with cold atoms in optical lattices. Continue to investigate compact sources of high-frequency pulsed radiation and very high peak-power sources of both electromagnetic and particle radiation. Explore techniques in micro- and nano-fabrication that better lend themselves to affordable, high-volume fabrication of ultra-high-frequency, compact high-power electromagnetic radiation sources. Continue examination of materials science innovations that promise to advance the state-of-the-art in low work-function field-emission (cold) high current density cathodes. Continue innovations in 3-D hybrid modeling of high power microwave sources with emphasis on parallel computing technology to speed execution times. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
	5.481	5.948	6.513	0.000	6.513

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Advance technologies for space sensors, imaging, identification and tracking methods, and effective space situational awareness. *FY 2009 Accomplishments:* In FY 2009: Investigated fundamental limits affecting ground-based and space-based surveillance of space objects. Developed improved adaptive optics and post-processing techniques for improved image resolution. Studied spectral, polarimetric, and temporal approaches to unresolved space object identification. Continued 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. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Continue to develop new sensing modalities that reduce limits on optical resolution and precision tracking of space objects. Investigate new methods of uniquely identifying unresolved space objects and incorporate this investigation in the identification of uncorrelated space objects. Continue study of the physics of signatures in the scattering and reflection of light during active imaging. Expand research into fundamental processes and energy sources affecting satellite drag leading to improved understanding of precursors to atmospheric density variations. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612301: *Physics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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.	5.720	6.202	6.774	0.000	6.774
FY 2009 Accomplishments: In FY 2009: Emphasized development of cost effective micro satellites for space weather sensing. Investigated requirements of boundary conditions and initial values for driving space weather models. Exploited newly developed radio astronomy techniques for remote sensing the space environment in the continued search for understanding of fundamental physics and processes controlling solar, heliospheric, magnetospheric ionospheric, and thermospheric environments with a focus on improving our ability to forecast near-Earth space environment using first principles physics models. Expanded investigation of the fundamental plasma modeling theory using new electromagnetic, grid-free, full kinetic modeling techniques. Continued ground-based and space-based sensor technology development for remote sensing and in situ measurement of space weather conditions. 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. Analyzed 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 for satellite drag.					
FY 2010 Plans: 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Investigate proxy indicators of ionospheric and atmospheric processes that could be sensed using inexpensive but effective techniques. Investigate methods to exploit grid-free calculations of plasma processes in the magnetosphere and ionosphere as well as in the solar atmosphere and solar wind. Continue the study of energy flow between solar and terrestrial environments. Continue to study plasma instabilities and plasma processes in the equatorial and polar ionospheres. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
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. *FY 2009 Accomplishments:* In FY 2009: Investigated properties of coherently propagating ultra-short laser pulses through the atmosphere for their exploitation as high power microwave sources. Upgraded algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media so that simulation of various lasers can be realized. Initiated 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. Modeled 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; communicated these results to the airborne laser program and to the Air Force's Air Combat Command, for the latter's high altitude platforms. Verified the design of reconfigurable warheads through suitable timing/placement of micro-detonators as well as the effects of various metal inclusions on lethality. Continued to improve methods for recognizing and tracking targets and for penetrating coverings or other dispersive media that obscure targets. Pursued the design of electromagnetic sources which, with the help of novel	9.655	10.186	10.910	0.000	10.910

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
materials, can transmit optimized waveforms for a variety of surveillance purposes and write numerical code which allows the user to simulate these sources. *FY 2010 Plans:* In FY 2010: Increase research into the susceptibility to upset of various electronic circuits when exposed to suitable electromagnetic waveforms. Continue to pursue a deeper understanding of the propagation of ultra-short laser pulses through the atmosphere with emphases on managing their attributes as well as exploiting such potentials as sources of terahertz radiation, components of a long-distance spectroscope, and components of laser-guided bombs or ladar when cloud cover is present. Increase support for research into the possibility of identifying electromagnetic waveforms which are optimal from the perspective of instances of various dispersive media (foliage, clouds, buildings, airplane boundary layers), where optimality is defined as securing improved spatial resolution of objects obscured by such media. *FY 2011 Base Plans:* In FY 2011: Increase basic research support for designing small, highly directive sources which can provide both secure communication and sophisticated waveforms which optimally propagate through various dispersive media. Such sources will depend crucially on progress in the area of electromagnetic metamaterials and composites which could display attributes not currently available. These sources will also include semiconductor lasers which are optically pumped and, in addition, might be combined to form partially coherent beams which are predicted to be less disturbed by atmospheric turbulence than are standard fully coherent laser beams. Continue support of circuit upset research with emphasis on digital circuits. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	44.901	46.777	50.470	0.000	50.470

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Center for Microplasma Science and Technology (CMST). *FY 2009 Accomplishments:* In FY 2009: Created a National Center for the microplasma research field. *FY 2010 Plans:* In FY 2010: Not Applicable.	1.995	0.000
Congressional Add: Development of Deployable Biosensors *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* In FY 2010: Fundamental research in remotely controlling the operation of both nanofabrication equipment and nanoscale analysis tools while performing nano-related research.	0.000	1.593
Congressional Adds Subtotals	1.995	1.593

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602204F: *Aerospace Sensors.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602601F: *Space Technology.*											
• PE 0602605F: *Directed Energy Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612302: *Solid Mechanics and Structures*	16.921	19.666	20.683	0.000	20.683	19.663	18.848	19.955	20.903	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. The goals are cost-effective development and safe, reliable operation of superior Air Force weapon and defensive systems. Fundamental knowledge of "multi-functional" structures with smart materials, sensors, actuators, and control systems integrated to accomplish damage control, thermal management, vibration reduction, and reconfigurable shapes. Research topics include: the modeling of non-linear static/dynamic behavior of structures; mechanical reliability of micro-devices; design of multi-functional materials; mechanical behavior of nanomaterials; and composite materials for structures.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Explore the integration of advanced nano materials and devices into turbine engines, air vehicles, space systems, and other weapon systems, and develop new mechanics.	8.050	9.422	9.930	0.000	9.930
FY 2009 Accomplishments: In FY 2009: Continued research in the area of multifunctional hybrid composite systems for sensing and neutralization of exogenous threats to load-bearing capability. Conducted 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 developed the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. Continued developing and exploiting methods that combine information technology and multi-scale modeling in the design of new material systems.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: Expand research in the area of multifunctional materials and microsystems for autonomic sensing and self-diagnosis of exogenous threats. Continue research in the area of multifunctional materials and microsystems for reconfigurable structures allowing shape change and property tuning. Continue research in the areas of 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. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Analyze structural fatigue and mechanics, adaptive structures, and material properties to improve the design, robustness, and performance of air and space systems.	8.871	10.244	10.753	0.000	10.753

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Expanded the novel theoretical and experimental methods in morphing aircraft structures to achieve broader operational capabilities. Utilized novel actuation devices and materials for Air Force aircraft and space structural applications. Expanded the study of the science related to the acceptance into new structures of the novel materials developed under the advanced materials programs, and used the knowledge to develop new aerospace structural concepts. Continued the development of structural health monitoring sensors and techniques towards an integrated vehicle-wide approach. Consolidated an integrated approach to structural systems lifetime prognosis and reliability. Expanded the understanding of mechanical and dynamic behavior of micro-/nano-scale structures to generate novel structural concepts. Investigated nonlinear phenomena associated with the structural deformation and aero-elastic instabilities and limit-cycle vibration to include novel structural concepts. *FY 2010 Plans:* 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612302: *Solid Mechanics and Structures*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Continue to seek new and revolutionary flight structure concepts that will permit broader operational capabilities, a faster reconfigurable ability, and more affordable accelerated fabrication. Investigate new structures of novel materials developed under the advanced materials programs and identify a proof-of-concept demonstration. Expand the understanding of structural health monitoring sensors and techniques and test the developed new science under laboratory conditions. Enhance the understanding of dynamic and mechanical behavior of flight structures under extreme environments (intense vibration, nonlinear structural dynamics, unsteady aero-thermo-elastic effects, directed energy effects etc.) to increase operational survivability and mission success. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	16.921	19.666	20.683	0.000	20.683

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602201F: *Aerospace Flight Dynamics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602202F: *Human Effectiveness Applied Research.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612302: *Solid Mechanics and Structures*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0603211F: *Aerospace Structures.*											

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612303: *Chemistry*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612303: *Chemistry*	36.584	38.957	41.587	0.000	41.587	40.207	38.953	40.459	42.500	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Research and characterize molecular dynamics, reaction mechanics/interactions, and theoretical chemistry to model, predict, control, and exploit atomic and molecular energetics.	15.888	16.382	17.485	0.000	17.485
FY 2009 Accomplishments: In FY 2009: Continued to develop new capabilities to predict molecular and macroscopic properties of chemicals of interest to the Air Force. Explored properties and potential of nano-scale energetic materials. 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. Continued developing novel applications of catalysis and plasmonic structures for applications to propulsion, energetics, and sensing. Explored new concepts for closed-cycle hybrid chemical lasers.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612303: *Chemistry*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: Create a fundamental understanding of basic chemical and physical processes on the nanoscale. Develop methods that can describe material behavior from the atomic level through mesoscopic and macroscopic scales and simulate chemical processes to model bulk scale properties. Develop theoretical methods to predict energy and density of novel energetic materials. Explore methods to use catalysis to improve energy utilization and storage. Create new selective and sensitive sensors for detecting trace species. Perform experiments and simulations to understand chemical processes in space for situational awareness. Investigate processes needed to assess scalability of hybrid laser concepts. *FY 2011 OCO Plans:* In FY 2011 OCO: Not Applicable.					
MAJOR THRUST: Enhance fundamental understanding of polymer chemical structures, reactivity, molecular engineering, processing controls, and materials technologies.	11.707	12.698	13.510	0.000	13.510

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612303: *Chemistry*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Exploited nanotechnology to enhance functional and mechanical properties of polymers through controlled dispersion, distribution, and placement of the nano-entities for Air Force applications. Studied the controlled synthesis of new polymers with improved power generation and storage functions. Conducted the modeling, synthesis, and characterization of conjugated polymers to understand and enhance the charge mobility of organic based semi-conducting organics and polymers. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Explore organic transistors with flexibility, mechanical robustness, and higher performance or equivalent of a-Si transistors. Explore rewritable color 3-D hologram displays using photorefractive polymers. Assess feasibility of controlling chirality of molecular structures to achieve negative index behavior in the optical or Infrared range. *FY 2011 OCO Plans:* In FY 2011 OCO: Not Applicable.					
MAJOR THRUST: Characterize, model, and exploit the fundamental chemistry and physics that govern surface and interfacial degradation from completely frictionless to total deterioration." *FY 2009 Accomplishments:* In FY 2009: Continued to develop theoretical and predictive methods for the fundamental understanding of the structure and reactivity of surfaces and how surfaces interact with their	8.989	9.877	10.592	0.000	10.592

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612303: *Chemistry*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
environment at the interface. Investigated 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 in nano- composite lubricants that provide function over a wide variety of extreme environments, including space. *FY 2010 Plans:* 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 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. *FY 2011 Base Plans:* In FY 2011: Apply knowledge of chemical and morphological effects on degradation of simple surfaces towards development of theoretical and predictive models for degradation of complex and hybrid surfaces and materials across multiple length scales. Investigate fundamental chemistry and physics of surface wear driving towards a comprehensive understanding of the role of the chemical environment. Develop real-time nano-tribological instrumentation capable of in-situ friction, adhesion, and wear experimentation. *FY 2011 OCO Plans:* In FY 2011 OCO: Not Applicable.					
Accomplishments/Planned Programs Subtotals	36.584	38.957	41.587	0.000	41.587

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612303: *Chemistry*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602601F: *Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602602F: *Conventional Munitions.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612304: *Mathematics and Computing Sciences*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612304: *Mathematics and Computing Sciences*	28.707	33.208	37.697	0.000	37.697	36.221	37.258	39.215	41.193	Continuing	Continuing

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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Perform dynamics and control research to develop innovative techniques for design and analysis of complex control systems.	14.667	16.917	19.161	0.000	19.161
FY 2009 Accomplishments: In FY 2009: Further developed the design and analysis techniques 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. Continued developing control methodologies to improve non-equilibrium behavior of complex, unsteady fluid systems. Advanced image processing and sensor technologies for use in UAV controllers, smart munitions, and non-destructive testing of vehicles. Developed 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. Further developed theory and algorithms for specification, design, verification, and validation of distributed embedded systems. Studied novel devices to exploit nonlinear					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612304: *Mathematics and Computing Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
dynamic phenomena with a focus on detection, classification, and control systems for use in urban combat environments. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Further develop heterogeneous and mixed human-robot interaction concepts for the design and analysis of cooperative control systems in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, UAVs, and constellations of small satellites. Develop increased levels of high-confidence adaptive control and machine learning techniques for teams of micro air vehicles operating at various altitudes in complex environments to execute assigned missions with variable operator intervention. Continue development of control methodologies to improve non-equilibrium behavior of complex, nonlinear systems. Advance image processing and sensor					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612304: *Mathematics and Computing Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
technologies for use in cooperative teams of UAVs and smart munitions to include multiple target tracking, ownship and world state estimation. Continue development of mathematical control theoretic models that capture the robust, nonlinear, hybrid dynamics of microbiological systems. Further 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. Continue development of theory and algorithms for specification, design, verification, and validation of distributed embedded control systems. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
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. *FY 2009 Accomplishments:* In FY 2009: Developed 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. Enhanced the analytical tool developments in operation research, meta heuristic searches, and robust, stochastic optimization. Focused on developing innovative and accurate mathematical and numerical algorithms to improve modeling and simulation capabilities, including aerodynamics as applicable to a range of flight regimes such as hypersonics and Micro Air Vehicles. 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, air and space components, and system health and maintenance systems. Enhanced uncertainty analysis in non-linear models of aerodynamic flows and structural failure predictions. Developed mathematical models that are dynamically evolving that would deal with operational data that are possibly incomplete, uncertain, conflicting, or overlapping.	14.040	16.291	18.536	0.000	18.536

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612304: *Mathematics and Computing Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: Continue to support new theoretically rigorous and computationally effective mathematical methods for solving large, complex problems in logistics, system diagnostics/prognostics, air mobility contingencies, engineering design, target tracking, and strategic/tactical planning (including cooperative control) for battle space information management. Meta heuristic searches are being combined with rigorous search techniques, with emphasis on the mathematical underpinning and the establishment of rigorous error bounds when convergence to non-optimal solutions occurs. Continue developing mathematically rigorous numerical algorithms for enhancing the modeling and simulations of large, complex, multi-scale, and nonlinear systems and phenomena of interest to the Air Force. The application areas in plasma, aerodynamics, structural mechanics, and materials will emphasize the increasing challenges in capturing the unsteady, dynamic, multi-physics, and multi-scale nature of the					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612304: *Mathematics and Computing Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
problems. Continue to focus on uncertainty quantification and management based on combination of computational science, information theory, statistics, and probability to lead to better understanding and analysis of complex systems. Support development and integration of novel optimization strategies with high-order, time-accurate solutions for superior design of Air Force systems. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	28.707	33.208	37.697	0.000	37.697

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602201F: *Aerospace Flight Dynamics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602602F: *Conventional Munitions.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602702F: *Command, Control, and Communications.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603789F: *C3I Advanced Development.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601102F: *Defense Research Sciences*	**PROJECT** 612304: *Mathematics and Computing Sciences*

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612305: *Electronics*	36.876	40.401	45.066	0.000	45.066	43.056	42.368	44.526	46.763	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Investigate novel detector and electronic materials, device concepts, and circuit architecture and implementation schemes important to future military space platforms.	8.790	9.821	10.987	0.000	10.987
FY 2009 Accomplishments: In FY 2009: Investigated 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. Investigated 'smart' reconfigurable materials whose properties can be dynamically tailored via self-programming or system software in response to changing behavior or mission needs. Focused on novel 'programmable pathways' to enable tailoring novel hybrid material systems such as metamorphic and heterogeneous systems.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: Continue investigating novel multi-modal electromagnetic spectra detection approaches and concepts utilizing increased understanding of phenomenological interactions between target/background radiation and novel nano-materials, -structures, and -devices. Specific emphasis will be placed on achieving material structures yielding linearly-graded semiconductor bandgap behavior or capable of dynamic bandgap tuning over the range ~ 0.2 - 2.5eV. In addition, novel materials and/or device structures capable of dynamic absorption coefficient tuning will be studied, along with concepts for thin-film spectra-filter tuning. Continued emphasis shall be placed on physics controlling semiconductor hetero-interface band misalignments that critically control carrier transport properties; controlling these alignments is an elusive holy grail for semiconductors that would lead to a plethora of game changing electronic and photonic device capabilities. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Investigate quantum and optoelectronic materials/devices, memory, and information processing, and nano-science for wide-field spectral sensors and critical, high-speed communication.	15.141	15.801	16.967	0.000	16.967

FY 2009 Accomplishments:

In FY 2009: Investigated nonlinear optical and laser materials, devices, and fabrication processes for radiation protection, cloaking and tracking, and target signature identification. Explored 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. Furthered the examination of advanced optical memory technologies for enhanced data storage, including negative index of refraction metastructures and photonic crystals. Investigated technologies for robust monolithic and miniature terahertz frequency spectrum devices, quantum cascade lasers, and plasmonics. Continued investigation of communication network technologies, room temperature ferromagnetic materials, and the interaction of system electronics and sensors with atmospheric and space environments.

FY 2010 Plans:

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 Radio Frequency 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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Continue advanced research efforts to better determine the optimal implementation of multi-ferroic materials for a wide variety of technologically advanced applications for the warfighter. Continue to explore the suitability of spintronic device elements that can be integrated into high performance ultra-miniature logic and control systems. Further explore special semiconducting and electronic materials that enable all photonic signal processing and logic technology, and begin to explore integration of these advanced technologies with RF Micro Electro-Mechanical Systems concepts. Further explore wide band gap semiconductors for high performance, high power RF applications with an in-depth understanding of device reliability issues. Continue research on special materials and nanostructures that will permit an expansion of device functionality beyond the current limits on silicon technology. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Exploit advances in nanotechnology to support multi-spectral detection technology, chip-scale optical networks, and compact power. *FY 2009 Accomplishments:* In FY 2009: Exploited controlled 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 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. Explored nanophotonic concepts for information processing components and systems. *FY 2010 Plans:* 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	6.264	7.161	8.328	0.000	8.328

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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, Complimentary Metal-Oxide Semiconductor - 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. *FY 2011 Base Plans:* In FY 2011: Pursue research in light localization below the wavelength scale, using concepts of plasmon optics, photonic crystal, and metamaterial nanophotonics for ultra-compact integrated photonic systems, ultra-compact optically functional devices, light-harvesting elements for molecular and nanocrystalline-based photovoltaic devices, lithographic patterning at deep sub-wavelength dimensions, and aberration-free lenses that enable optical imaging with unprecedented resolution. Continue to exploit silicon-compatible components for photonics and take advantage of the mature processing and manufacturing expertise that silicon technology affords. Pursue smaller and more highly integrated optical subsystems for telecommunications applications and high speed processing. Explore thermoelectric applications of silicon and germanium based nanomembranes made into nanowires and nanoribbons plus nanowire photovoltaic devices. Enhance solar-energy conversion through plasmon enhanced photovoltaic films, and investigate the feasibilities of nitride based and non-traditional material nanostructures for applications in photoelectrochemical cell technology, and thermoelectric device technology. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Investigate quantum electronic solids phenomena to explore superconducting, magnetic, negative index, and nanoscopic materials.	6.681	7.618	8.784	0.000	8.784
FY 2009 Accomplishments: In FY 2009: Constructed and tested a low-noise, wide-bandwidth amplifier by using improved planar thin-film Josephson-junction technology. Attempts to fabricate high-temperature, high-performance magnetic materials were 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 were augmented as the tape technology continued to reach desired goals. Progressed in seeking practical negative index materials over a broad range of frequencies. Nanoelectronic circuitry based on nanomaterials and new concepts also received added emphasis in attempting to promote miniaturization, greater functionality, and lower losses. Continued searches for new higher-temperature (and practical) superconductors.					
FY 2010 Plans: In FY 2010: The program discovers more useful, economical superconductors for power and electronic applications progress has been made toward identifying promising materials, new advances in physics, chemistry and materials science. Further exploration in superconducting electronics using both magnesium diboride and yttrium-barium-copper-oxide superconducting films is planned to determine whether these unique structures have a potential to become the basis for improved radar systems. Research continues 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 form to produce sub-wavelength imaging. Continue studying denser memory elements using crossbar architecture in contact with standard CMOS circuitry.					
FY 2011 Base Plans: In FY 2011: The use of implanted defect structures in diamond films utilizes a system of addressable electron spin states that are manipulated and entangled so that concepts in quantum information science are tested at room temperature. Continue investigation of nanoelectronic elements utilizing					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612305: *Electronics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
carbon nanotubes that form the basis for a new generation of sensors and circuit elements. Metamaterials research continues to produce more efficient and smaller, omni-directional antennas. Investigation of superconductors produce several new superconducting materials, and research begins on making larger quantities and better quality specimens of said materials to determine cost effectiveness. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	36.876	40.401	45.066	0.000	45.066

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602204F: *Aerospace Sensors.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602702F: *Command, Control, and Communications.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603203F: *Advanced Aerospace Sensors.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603789F: *C3I Advanced Development.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612306: *Materials*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612306: *Materials*	24.104	29.321	32.040	0.000	32.040	31.134	30.964	32.611	34.225	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Perform non-metallic, ceramic, and hybrid materials research to identify/design new materials and composites with very-high (>1400F) and ultra-high (>2500F) temperature.	11.599	11.966	12.872	0.000	12.872
FY 2009 Accomplishments: In FY 2009: Continued optimizing the design of multi-functional structural ceramics materials to enable structurally enhanced smart systems for application in extreme environments. Expanded the development of new approaches in improving the thermal and mechanical stability of ceramic and metallic composites for aerospace applications. Explored the role of the operational environment on					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612306: *Materials*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
the mechanisms of failure in hybrid materials. Expanded the development of innovative concepts for developing higher temperature and more damage-tolerant organic, inorganic, and polymer matrix composites. Continued to expand the development of the fundamental knowledge base to exploit the use of nanomaterials and nanocomposites in aerospace structures. *FY 2010 Plans:* 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. Continue investigating interfacial properties of hybrid materials and their influence on component durability. Continue further study into damage initiation due to oxidation of high temperature polymer matrix composites. *FY 2011 Base Plans:* In FY 2011: Impact of incorporation of carbon nanotubes in carbon fibers. Further study nano-particle incorporation in thermoplastic composites to improve its crystallization rate in filament winding conditions. Further investigation of the influence on nanoparticle networks within amorphous materials on the high temperature mechanical properties. Continue modeling of interfacial properties between matrix and fiber in fiber reinforced composites. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Perform research in metallic, ceramic and hybrid materials to understand their properties at temperatures above 1000C. *FY 2009 Accomplishments:* In FY 2009: Investigated nano-laminates and nanocomposites for aerospace armor and small air-vehicle structures. Explored the interaction between chemistry and mechanics in the surfaces and interfaces of these nanoscale structures. Further explored the processing and development of	12.505	12.872	13.779	0.000	13.779

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612306: *Materials*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
multifunctional structural metals for power systems and space applications. Developed and verified multi-scale models to study the response of aerospace alloys exposed to corrosive environments and cyclical loading. Continued development of an informatics process to exploit disparate sources of materials' properties data derived from modeling and experimentation. Continued research on the fundamental science of friction and thermal effects during friction stir processing. Investigated affordable and environmentally sustainable methods to process aerospace alloys. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Continue optimizing the thermal and mechanical stability of high temperature aerospace materials for air and space applications. Exploit new approaches to designing hybrid high temperature materials and to enhance performance in harsh thermal environments. Further examine innovative concepts for developing stronger and more damage-tolerant high temperature hybrids materials. Further explore opportunities to reduce system weight and/or size, increased operational lifetime, and high temperature performance of aerospace structures. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Explore mimetics, natural materials, and natural/synthetic interfaces.	0.000	4.483	5.389	0.000	5.389

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612306: *Materials*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Not Applicable. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Continue work on manipulating materials to mimic the desirable properties found in autonomous materials for sensing, maintenance, self-healing and repair. Further investigate predator avoidance and new prey detection schemes as future technology areas. Continue to 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612306: *Materials*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Continue research of natural materials' extension into new electronic and photonic systems by utilizing the self-assembly of these materials into unique electronic and optical architectures for Intelligence Surveillance Reconnaissance applications. Will research the manipulation of natural systems in order to develop new synthetic avenues to produce unique material properties and systems. Further explore 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. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	24.104	29.321	32.040	0.000	32.040

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602201F: *Aerospace Flight Dynamics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602601F: *Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603211F: *Aerospace Structures.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0708011F: *Industrial Preparedness.*											

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612307: *Fluid Mechanics*	19.346	25.706	26.800	0.000	26.800	26.226	26.394	27.830	29.182	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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 systems.	8.205	8.452	9.348	0.000	9.348
FY 2009 Accomplishments: In FY 2009: Extended efforts to characterize and model fundamental phenomena of high-speed boundary laminar-turbulent transition to include interactions between multiple instability modes. Validated high-fidelity, unsteady numerical simulation methodologies for shock-dominated flows and non-equilibrium effects. Extended strategies for control of excessive heat transfer, unsteadiness, and					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
separation in hypersonic flows to reduce severe local loads on systems. Explored 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. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Characterize and model fundamental phenomena of high-speed boundary layers, including interactions between multiple instability modes in laminar-turbulent transition and the influence of realistic surface conditions including roughness, ablation and surface chemistry. Continue validation of high-fidelity, unsteady numerical simulation methodologies for shock-dominated flows, including non-equilibrium effects and laminar-turbulent transition and implementation of potential control methods via simulation of benchmark canonical problems. Refine strategies for control of excessive heat transfer, unsteadiness, and separation in hypersonic flows to reduce severe local loads on systems. Develop multidisciplinary simulation capability for prediction of 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 OCO Plans: In FY11 OCO: N/A					
MAJOR THRUST: Expand fundamental knowledge of unsteady flows in integrated theoretical, experimental, and computational efforts. Study complex flow phenomena related to unsteady phenomena. *FY 2009 Accomplishments:* In FY 2009: Continued to develop reduced order, closed-loop flow control mechanisms on unsteady flows of complex geometries and jet engines and identified specific applications to transition technology. Characterized and modeled promising applications of flow control techniques to improve jet engine integration and efficiency for a wider range of flight operating conditions. Validated tools for predicting and controlling unsteady, vortex-dominated flows on UAVs. Continued to develop innovative techniques for improving convective heat transfer at all flow scales to enhance thermal management of subsonic and supersonic flight systems. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Develop physically accurate descriptions of unsteady flows over complex geometries and highly flexible structures. Derive and assess reduced order models of canonical flow problems that lead to robust, closed-loop flow control approaches. Refine modeling of promising flow control techniques to optimize fluid-structure interactions and aerodynamic efficiency for a wider range of flight operating conditions. Continue validation of tools for predicting and controlling unsteady, vortex-	9.146	9.393	10.288	0.000	10.288

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
dominated flows on UAVs in a range of scales. Develop numerical tools for multidisciplinary simulation of unsteady fluid-structure interactions. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
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 mechanisms. *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* 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. Develop and test neuromorphic emulations to enable adoption in engineered technology for autonomous or semi-autonomous air vehicles. *FY 2011 Base Plans:* In FY 2011: Investigate natural flight capabilities applicable to multiple, coordinated air vehicles operating in cluttered and/or unpredictable environments. Develop mathematical approaches for intelligent, autonomous flight control and navigation in multi-vehicle arrays and cooperative swarms, based upon natural systems of sensing and guidance, with emphasis on possible applications to small UAVs operating in low Reynolds Number regimes. Continue to develop mathematical and neuromorphic algorithms based upon sensorimotor information processing to enable new capabilities in autonomous flight.	0.000	6.268	7.164	0.000	7.164

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 OCO Plans: In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	17.351	24.113	26.800	0.000	26.800

	FY 2009	FY 2010
Congressional Add: Development and Validation of Advanced Design Technologies for Hypersonic Research (National Hypersonic Research Center). *FY 2009 Accomplishments:* In FY 2009: Continued research on experimental and numerical simulation to characterize and develop predictive numerical methods for physical phenomena associated with hypersonics. *FY 2010 Plans:* In FY 2010: Not Applicable.	1.995	1.593
Congressional Adds Subtotals	1.995	1.593

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602201F: *Aerospace Flight Dynamics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612307: *Fluid Mechanics*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0603211F: *Aerospace Structures.*											

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612308: *Propulsion*	24.669	32.115	34.022	0.000	34.022	32.772	32.599	34.335	36.057	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Research and model space propulsion and power in the areas of chemistry, electronics, miniaturization, and contamination/signature.	10.951	11.576	12.477	0.000	12.477
FY 2009 Accomplishments: In FY 2009: Continued studies of small satellite, microsatellite, and nanosatellite propulsion and investigated plasma dynamics in these thrusters. Investigated high altitude plumes signature and contamination. Continued investigating alternate launch systems using electromagnetic forces. Conducted fundamental component and system level research that leads to introduction of novel multi-use technologies and concepts to achieve multi-functional satellite architectures and development of					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. Enhanced novel diagnostic techniques for characterization of combustion instabilities in high pressure, harsh, optically thick environments. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: Continue the study of novel energetic propellants for space propulsion, including nano-aluminum, ammonium borane, silicon, and hydrogen peroxide to achieve cryogenic propellant performance with non-cryogenic propellants in both launch and in-space systems. Continue investigation of nano-energetics in liquid and gel propellants to increase specific impulse in liquid propulsion systems, and study the dynamic behavior of such systems, including three-phase, high-pressure, and temperature combustion phenomena. Continue investigating alternate launch systems using electromagnetic forces and beamed energy. Continue to investigate new electric propulsion concepts for nano, micro, and macro satellites, including electrodeless and propellantless systems, and power regeneration through thermoelectric materials. Conduct research on near-space propulsion alternatives, including air-breathing plasma propulsion systems.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 OCO Plans: In FY 2011 OCO: N/A					
MAJOR THRUST: Explore combustion, propulsion, and diagnostics in subsonics, supersonics, and hypersonics. Investigate multi-phase, turbulent reacting flows. *FY 2009 Accomplishments:* In FY 2009: Improved laser diagnostic measurement capabilities, investigations of molecular transport effects causing and enhancing thermal destabilization of hydrocarbon fuels under supercritical thermodynamic conditions, and prediction methodologies, which are both quantitatively accurate and computationally tractable, for turbulent combustion models. Further explored the scientific bases for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies. Exploited 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, identified surrogate fuels that represent the behavior of current and future alternative fuels through chemically simplified chemical compounds that retain the energy conversion characteristics of the base fuels. *FY 2010 Plans:* 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	12.920	13.547	14.449	0.000	14.449

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
studies of novel propulsion system design based on alternative fuel properties to achieve optimization with respect to performance, environmental impact, cost, and assured supply. *FY 2011 Base Plans:* In FY 2011: 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 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, continue studies of novel propulsion system design based on alternative fuel properties to achieve optimization with respect to performance, environmental impact, cost, and assured supply. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Identify, characterize, and bioengineer photosynthetic and/or non-photosynthetic microorganisms and their metabolic pathways. *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* 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	0.000	6.195	7.096	0.000	7.096

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. *FY 2011 Base Plans:* In FY 2011: Continue to studay biosolar hydrogen to manipulate the photosynthetic flow of electrons to the hydrogen-generating enzyme by eliminating and/or adding genes that code for alternative pathways of electron flow and for the oxygen-sensitive inhibition of the hydrogen-generating enzyme. Continue bio-prospecting research to identify and clone unique algal oil-generating genes that metabolically engineer into one strain, optimizing the control and enhancement of algal oil for use as a future source of jet fuel. Continue to identify and map the interaction of metabolic pathways involved in controlling and channeling electrons from photosynthesis to the oil-producing pathways in microalgae. Continue research on microbial fuel cells by exploring and characterizing newly discovered bacterial nanowires to understand their role in transporting electrons from microbial biofilms to electrodes, and begin to identify microbial genes involved in extracting electrons from the cathode to reduce oxygen and enhance power generation. Also, continue the research on enzymatic fuel cells by utilizing thermophilic enzymes, self-assembly mechanisms, active-site analysis, and bioengineering to create novel, resilient pathways for the complete and efficient oxidation of multiple biofuels to enable enhanced compact power production. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	23.871	31.318	34.022	0.000	34.022

FY 2009	FY 2010
0.798	0.797

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612308: *Propulsion*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Coal Transformation Laboratory. *FY 2009 Accomplishments:* In FY 2009: Conducted 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. *FY 2010 Plans:* In FY 2010: Not Applicable.		
Congressional Adds Subtotals	0.798	0.797

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602601F: *Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603211F: *Aerospace Structures.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612311: *Information Sciences*	29.698	51.026	53.143	0.000	53.143	52.784	54.630	57.314	60.208	Continuing	Continuing

Note

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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Explore basic mechanisms to realize gains in innovative transformational communications technologies, enabling enhancement to its dominance communications using the space medium.	1.000	0.000	0.000	0.000	0.000
FY 2009 Accomplishments: In FY 2009: Continued 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. Monitored the polarization states to verify the predicted long distance stability.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: In FY 2010: Not Applicable. *FY 2011 Base Plans:* In FY 2011: Not Applicable. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Conduct fundamental research in signals analysis for enhancement of sensing, surveillance, and targeting capabilities, increased awareness, and improved reaction/response. *FY 2009 Accomplishments:* In FY 2009: Studied 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. Continued to develop ultra-wide band transmission technology for hyper-spectral and other diverse data. Studied methodologies for evaluating the performance of new wireless mobile, networked communications systems. Studied and assessed technical alternatives for feasibility of super-resolution millimeter and search and rescue imagery. *FY 2010 Plans:* 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 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.	6.129	9.880	12.180	0.000	12.180

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Conduct further research in innovative sensing and multi-modal data acquisition, and promote the ways and means for integration of electro-optical, radar, ladar, and inertial systems with global positioning satellite (GPS) in electromagnetically and physically challenged environments. Scientific issues connected with radar imaging (and target identification) include the determination of advantageous classes of transmit waveforms, for bi-static, multiple-output, or some other distributed set-up, together with the needed conceptual mathematics and computational techniques. Covertness and encryption requirements in "free-space" communication lead to problems of information theory/ optics whose solutions provide new methods of sequence key encryption. In precision navigation and timing, new basic results in the integration of sensing GPS data over multiple platforms are needed. Progress in this domain will facilitate confident actions under many military scenarios, such as the mutual updating of geo-location and timing data for a group of unmanned aerial vehicles, allowing their seamless cooperation for surveillance, pursuit, and attack. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Conduct research in complex systems and algorithms for highly flexible, reliable, secure, and rich information systems supporting battlefield commanders using artificial intelligence. *FY 2009 Accomplishments:* In FY 2009: Increased emphasis on investigating first principles of software system architectures including characteristic properties and metrics, and began development of automatic software architecture analysis tools. Conducted research on brilliant software agents and other techniques for information operations, knowledge mining, and to improve situational awareness and command and control. Continued to develop information operations science techniques to exploit information intensive systems and networks. Continued developing information fusion science to provide deep, adaptive, and expert decision support.	22.569	25.318	27.617	0.000	27.617

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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 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. *FY 2011 Base Plans:* In FY 2011: Increase emphasis on developing a science of cyber security. Develop new software systems modeling techniques that incorporate human behavioral models into software architectures to capture fundamental human-computer interaction. Initiate information operations research on artificial diversity. Expand research on how fundamental mathematical methods translate into improved reliability and security of existing and future networks. Continue developing fundamental science of information integration and fusion that provides for situation and impact assessment to achieve predictive response. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Evaluate fundamental mechanisms and build mathematical descriptions of cognitive decision-making, including adaptation to non-cooperative interactions. *FY 2009 Accomplishments:* In FY 2009: Not Applicable.	0.000	11.047	13.346	0.000	13.346

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: Continue to investigate high-order cognitive processes, and explore new mathematical frameworks to enable, in a principled way, upward scaling of cognitive information processing approaches from simpler to more complex and realistic decision-making tasks. Develop and test algorithms for applications in reinforcement learning, sequential sampling, kernel-based classification and generalization, Bayesian forecasting, and optimization of attentional resources. Develop new techniques to understand, measure, and control informational masking to enhance speech communication and situational awareness. Investigate the fundamental constraints and limits of computationally-based socio-cultural prediction, including scalability from individual or small groups to larger coalitions. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	29.698	46.245	53.143	0.000	53.143

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Process Integrated Mechanism for Human-Computer Collaboration and Coordination *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* In FY 2010: Enhance fundamental understanding in a process integrated mechanism, which ties together computers and humans into a single collaborating system by virtue of a single program that rapidly moves among all computers in the system.	0.000	0.797
Congressional Add: Safeguarding End-User military Software *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* In FY 2010: Conduct fundamental multi-disciplinary research associated with the further safeguarding of military software.	0.000	3.984
Congressional Adds Subtotals	0.000	4.781

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602601F: *Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612311: *Information Sciences*	

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602702F: *Command, Control, and Communications.*											
• PE 0603410F: *Space System Environmental Interactions Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603500F: *Multi-Disciplinary Advanced Development Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612312: *Biological Sciences*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612312: *Biological Sciences*	9.831	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Characterize, understand, predict, control, and engineer biomolecular responses induced in organisms by chemical and physical agents of Air Force significance.	5.570	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612312: *Biological Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Began 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. Collected data from biological systems exposed to nano-materials and began to develop a data base of responses for future predictive modeling studies based on physico-chemical properties of various nanostructures. Collected direct energy dose-response data and began bioinformatics analyses to identify unique biomolecular profiles responding to specific levels of radiant exposure. Continued bio-prospecting, bio-engineering, and directed-evolution approaches to the generation of hydrogen fuel by photosynthetic microbes and began metabolic engineering research to identify and eliminate pathways that drain unnecessary energy equivalents away from the hydrogen-generating apparatus. Utilized state-of-the-art tools and techniques to explore, collect, and analyze data with regard to low-dose chemical and radiation exposure effects, and the molecular pathways and profiles mediating the responses to the exposures. *FY 2010 Plans:* In FY 2010: Not Applicable. *FY 2011 Base Plans:* In FY 2011: Not Applicable. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Explore biomimetics, biomaterials, and biointerfacial sciences to enable development of novel sensors, engineering processes, and mechanisms, and the synthesis of novel materials. *FY 2009 Accomplishments:* In FY 2009: Conducted research on manipulating materials to mimic the desirable properties found in skin for maintenance, self-healing, and repair. Expanded investigating predator avoidance	4.261	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612312: *Biological Sciences*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. Exploited biomaterial and biointerfacial sciences to control cellular systems to synthesize novel materials, evaluate biosensors, and elucidate bionanotechnology applications. Researched surface mediated cellular differentiation as a new sensor modality. 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. *FY 2010 Plans:* In FY 2010: Not Applicable. *FY 2011 Base Plans:* In FY 2011: Not Applicable. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	9.831	0.000	0.000	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602202F: *Human Effectiveness Applied Research.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602204F: *Aerospace Sensors.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612312: *Biological Sciences*	

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602602F: *Conventional Munitions.*											
• PE 0602702F: *Command, Control, and Communication.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612313: *Human Performance*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
612313: *Human Performance*	14.319	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Probe human sensory systems and perceptions critical for warfighter performance (auditory and visual processes, multi-sensory integration, and sensory biomimetics).	6.021	0.000	0.000	0.000	0.000
FY 2009 Accomplishments: In FY 2009: Engaged new research methods to characterize requirements for optimal speech communication, including modulation representation and filtering. Developed 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, developed and tested theoretical models					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 612313: *Human Performance*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
for bone- and tissue-conducted cochlear excitation in high-noise environments. Improved ability to understand and forecast cognitive impairments during continuous high workload conditions by employing new genomic and brain-monitoring methods to identify biomarkers for individual susceptibility. Devised 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"). *FY 2010 Plans:* In FY 2010: Not Applicable. *FY 2011 Base Plans:* In FY 2011: Not Applicable. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Evaluate cognition and perception research in complex, multi-interaction command and control tasks. *FY 2009 Accomplishments:* In FY 2009: Probed 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. Continued 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. These new efforts promoted cross-disciplinary contributions from brain science, operations research, network theory, and computer science. *FY 2010 Plans:* In FY 2010: Not Applicable.	8.298	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Not Applicable. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	14.319	0.000	0.000	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602202F: *Human Effectiveness Applied Research.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602702F: *Command, Control, and Communication.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 614113: *External Research Programs Interface*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
614113: *External Research Programs Interface*	11.879	9.701	9.470	0.000	9.470	9.296	9.472	9.838	10.273	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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Foster international science and technology cooperation by supporting the Air Force's international strategy mission. Identify and obtain unique foreign research capabilities.	6.443	5.354	5.238	0.000	5.238
FY 2009 Accomplishments: In FY 2009: 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.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 614113: *External Research Programs Interface*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: 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. *FY 2011 Base Plans:* In FY 2011: 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. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Strengthen science, mathematics, and engineering research and educational infrastructure in the U.S., thereby strengthening Air Force technical capabilities.	5.436	4.347	4.232	0.000	4.232

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 614113: *External Research Programs Interface*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Supported science, mathematics, and engineering research, and educational outreach programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and other minority institutions. Increased awareness of Air Force research needs throughout civilian scientific community, while simultaneously identifying/recruiting the best scientific talent to participate in critical Air Force research. *FY 2010 Plans:* 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. *FY 2011 Base Plans:* In FY 2011: 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. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	11.879	9.701	9.470	0.000	9.470

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 614113: *External Research Programs Interface*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0601103D: *University Research Initiative.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602201F: *Aerospace Flight Dynamics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602202F: *Human Effectiveness Applied Research.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602204F: *Aerospace Avionics.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602269F: *Hypersonic Technology Program.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602500F: *Multi-Disciplinary Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602601F: *Space Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602602F: *Conventional Munitions.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602702F: *Command, Control and Communication.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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.